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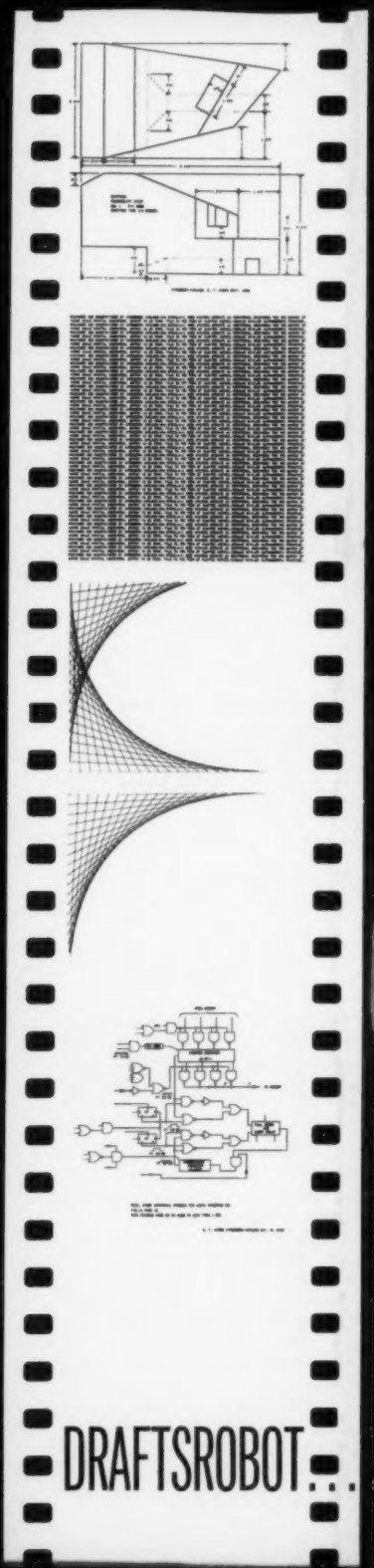
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS • JANUARY 30, 1961



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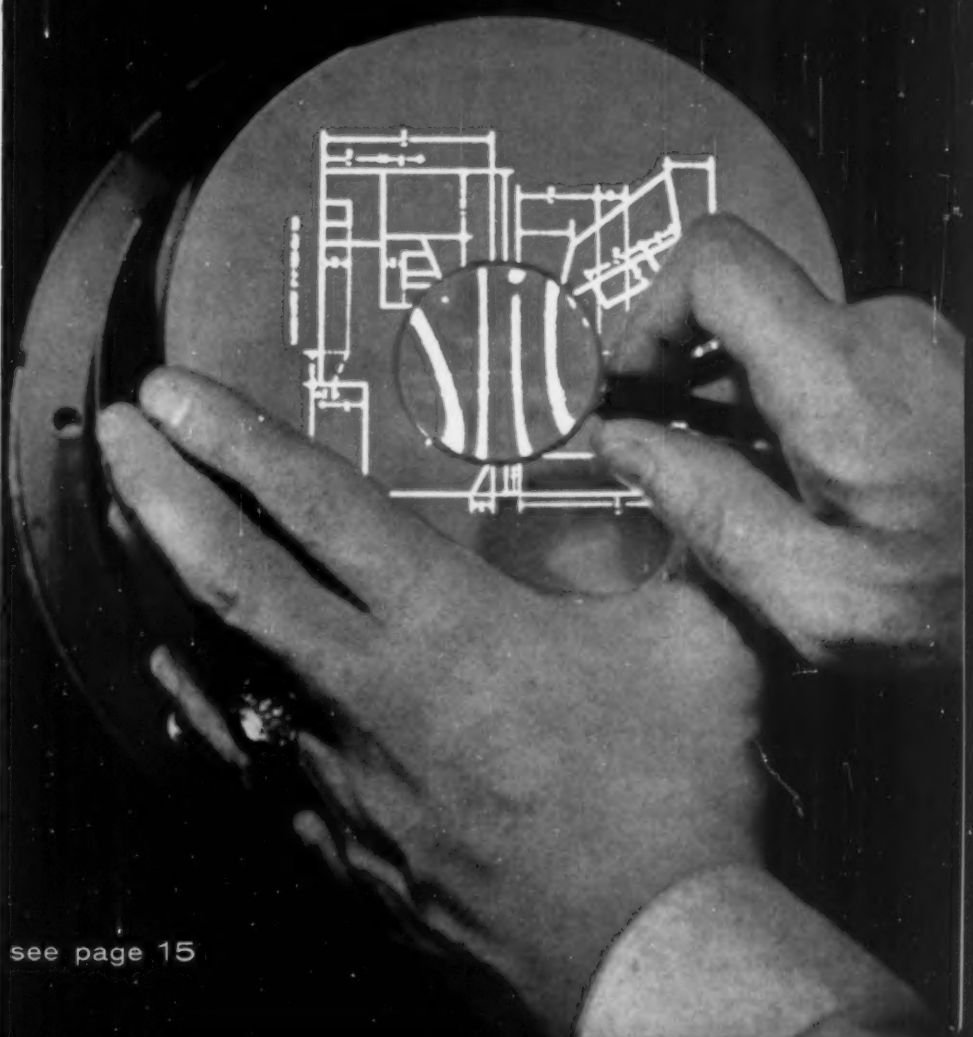

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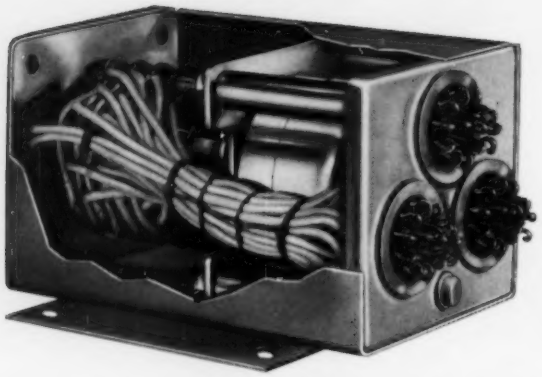
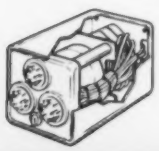


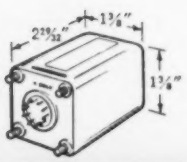
Ledex

Hermetically Sealed Rotary Switch

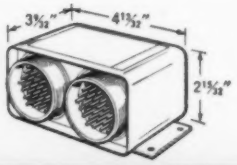
BASIC INFORMATION



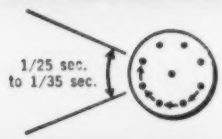
Hermetically sealed switches are permanently protected from moisture, dust, fungus, corrosion and tampering.



Small size 2E Circuit Selector can provide a 1-pole 12-throw, 2-pole 6-throw or 3-pole 4-throw. Weight 3½ oz.

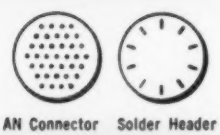


Larger size 3 Circuit Selector is available in many combinations, as 22-pole 2-throw, 12-pole 4-throw, 4-pole 12-throw.

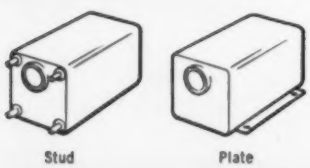


Selectors will step to any pre-selected position at 25 to 35 steps per second.

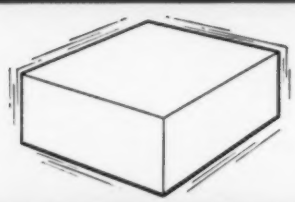
Wiping-type contacts are self-cleaning, reduce film problems of "dry" circuits. Shorting or non-shorting contacts.



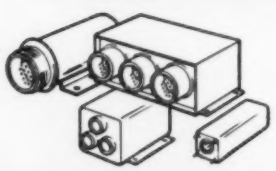
Any standard commercial connector can be used.



Switch housings come with stud or plate mounting. Specials on request.



Sealed units to meet missile-age vibration and shock requirements.



Wide selection of stepping switches as well as circuit selectors available in protective housings.

Hermetically Sealed Circuit Selectors and Stepping Switches contain an atmosphere of dry nitrogen which provides a permanent environment for the operation of the switch. They are designed to meet MIL-E-5272A, and will withstand extreme moisture and high altitude conditions in military and industrial installations. Sealed Switches are available in various wire sizes for operation from 6 to 350 VDC. Self-contained plug-in types allow rapid field installation. More than 3000 standard designs are shown in Bulletin D-460.

Other Ledex products include Rotary Solenoid, *Syncramental* Stepping Motor, *Digimotor* Stepping Motor and Indexing Device, Rotary Solenoid Selector Switch, *Digimotor* Selector Switch.

Switching applications include circuit selecting, stepping, counting, programming and sequencing.

Mechanical applications of other Ledex products include actuation of valves, vanes, printers, shafts. Write for literature, mentioning application, to Ledex Inc., Dayton 2, Ohio; Marsland Engineering, Ltd., Kitchener, Ont.; NSF Ltd., 31 Alfred Place, London, Eng.; NSF GmbH, Nurnberg, Germany.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

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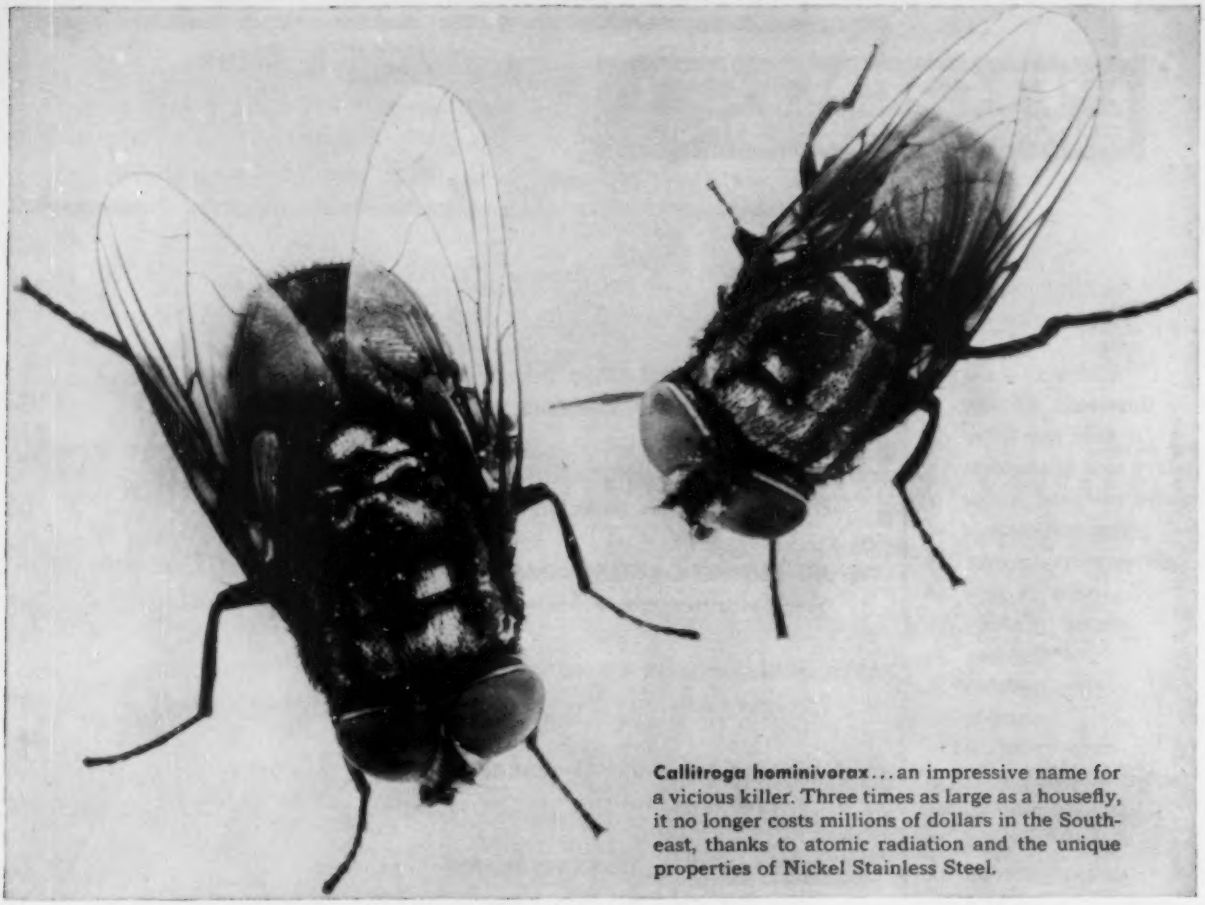

Callitroga hominivorax... an impressive name for a vicious killer. Three times as large as a housefly, it no longer costs millions of dollars in the Southeast, thanks to atomic radiation and the unique properties of Nickel Stainless Steel.

Atoms clobber a $20-million-a-year pest

How Nickel Stainless Steel helped fight costly cattle menace

A few small flies can kill a full-grown steer in ten days.

They call this killer *Callitroga hominivorax*, or screwworm fly. It used to cost Southeast cattlemen 20 million dollars a year.

Thanks to a peaceful use of atomic energy, the U.S. Department of Agriculture reports that *Callitroga hominivorax* was completely eradicated within seventeen months. This achievement may mark a new precedent in modern methods of pest elimination. Over two billion laboratory-raised male flies were sterilized by atomic radiation and then released. Because the females then laid sterile eggs, the screwworm fly population was destroyed.

Sterilization was accomplished by exposing males to gamma radiation from Cobalt 60 within a lead-shielded cask of Nickel Stainless Steel.

Nickel Stainless Steel was chosen by the designers, Knapp Mills Inc., for several reasons. It gives strength and rigidity to the cask's interior for greater handling safety. It stands up to the nitric acid solution used for radioactive decontamination — a cleaning process that plays havoc with less corrosion-resisting metals. And its sanitary, attractive appearance adds sales appeal to any product.

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THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

The Irradiator, nemesis of screwworm flies, is fabricated of Nicrolum*—a Nickel Stainless Steel to which lead has been metallurgically bonded. Six of these machines brought the fly menace under control.

*T.M. of the designer-manufacturer, Knapp Mills, Inc., Long Island City, N. Y.

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NICKEL MAKES ALLOYS PERFORM BETTER LONGER

INTERESTING TO NOTE

Electrical Frogs

One day in the late 1780s a shy, retiring professor of anatomy at the University of Bologna was performing a function that was almost commonplace with him—dissecting a frog. Suddenly, the legs of the dissected animal jerked, simultaneously with a discharge from a nearby electrostatic generator. The professor sought the reason and found it: ". . . While one of those who were assisting me touched lightly and by chance the point of his scalpel to the internal crural nerves of the frog, suddenly all the muscles of its limbs were seen to be so contracted that they seemed to have fallen into tonic convulsions." This discovery by Luigi Galvani was truly electrical—one of the most important in both anatomy and electricity.

Scientists throughout Europe began to investigate the strange phenomenon called "animal electricity." Some believed that certain animal tissues actually contained an electric charge. Others, like physicist Alexander Volta, went on in still another direction. He found he could also cause frog muscles to twitch by touching them with two dissimilar metals. The metals created the current, he reasoned; a nerve conducted this current, actuating the muscles.

Volta experimented for a decade, finally designing a cell consisting of a series of silver and zinc disks separated by a brine-soaked cloth. He was only able to generate a weak electrical charge, but enough to prove his dissimilar-metal theory.

In 1881, the International Electrical Congress honored Volta by naming the measure of electromotive force after him. Volta's name is further perpetuated by voltmeters and such a new concept in voltmeters is discussed on page 33. —Benedict A. Leerburger Jr.

SIDELIGHT

The following report, taken from a British publication, indicates there has been considerable development of a new science called antithetics. We have known many antitheticians-by-principle, but never realized the science had reached the stature indicated here.

Let the managing director of a large industrial company explain: he was, we're told, responsible for the appoint-

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ment of the first antithetician in England and, perhaps, in the world.

"Actually," he said, "the antithetician started as one of our bright chaps who always keeps abreast of everything in new ideas, new techniques, and new machines. We had a problem about our loading bays at one factory—I was getting really worried about them, for there always seemed to be a long queue of lorries waiting to be loaded. We have three bays altogether, so I said that if we put in another three the queue would only be half as long: that's

just common sense, isn't it? Still, common sense is not good enough nowadays, it seems. New capital projects all have to be vetted by the specialists. Of course, everyone passed this one except those work-study chaps—or was it that OR fellow? Anyway, someone said that one extra bay would be enough, and that if we put in three the third would be idle most of the time. Obvious nonsense, but they had bits of paper covered with those wretched squiggles they use. It was all beyond me completely, so I had to ask John here if he could prove them wrong."

The antithetician took up the story.

"It wasn't too difficult, really. First I saw that they had assumed Poissonian arrivals—an obvious oversimplification. They had also taken a constant loading negative exponential distribution. The limits for one of the integrations were rather dubious, and the length of the lorries had been ignored. Oddly enough, they had apparently arrived at the right answer in spite of it all but, as I pointed out to the managing director, one could hardly accept criticism of his project on the basis of such slovenly mathematics."

This, then, was how the company came to appoint the first antithetician, the man whose sole task is to oppose the arguments of any other specialist in his own terms. Like a lawyer, he is not concerned with the rights or wrongs of the case, but only with the job of demolishing it.

One of the attractive features of antithetics is that no problem is too big or too small, too particular or too general, to be outside its scope. Such a startling new advance in management technique is not likely to remain the exclusive property of one company. Although other British firms have shown a regrettable reluctance to adopt antithetics on a large scale (or, indeed, on any scale at all), the idea has spread like a new religion throughout the United States. Most of the larger corporations have set up impressive departments, although across the Atlantic they prefer to be known as Contradiction Counselors: their recently formed society is already a thousand strong. The new science has progressed far beyond its humble origins, and plans to organize the First International Conference on Antithetics are well advanced: it will probably be held in Paris in the spring unless someone comes up with a good reason why it shouldn't.

NEXT WEEK IN PRODUCT ENGINEERING

. . . **New Magnetic Test Includes Stainless Steels**
Particles suspended in a plastic solution show up defects that older techniques miss; flux pattern can be permanently recorded on a peel-off film.

. . . **Feeder Mechanisms—Analyzing Types**
How to perform schematic analysis of individual motions and translate them into mechanisms.

. . . **New Way to Find Natural Frequency of Vibration Isolators**
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. . . **Make Your Product Tests User Tests**
It is the only way to find out how successful your design really is.

. . . **6 Applications for Flat Washers**
Illustrations show where and how to use them.

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WHAT'S HAPPENING IN RESEARCH . . .

Creep tests reported for manganese steels

Silicon-killed, low-carbon, high-manganese steels show better creep resistance and stress rupture strength than those treated with aluminum. British metallurgists J. M. Robertson and R. W. Nichols reported to a British Iron & Steel Institute symposium.

Tests at C A Parsons & Co Ltd and UKAEA Culcheth laboratories indicate that after 200,000 hr at 750 to 800 F, the aluminum-grain-refined steel has a stress-rupture strength of about 18,500 psi; silicon-killed steel, more than 26,000 psi.

In creep tests, aluminum-treated steels developed a creep strain of 0.27 at stresses of 7500 to 8000 psi. The open-hearth silicon-killed steels shower higher values, through exact comparisons were not possible.

More data on cold-rolled titanium

High-purity titanium responds readily to cold rolling. Strength and hardness increase; and, while ductility decreases, it does not drop below 10%, even for a reduction of 40% or more. However, the latest Bureau of Mines report on electrorefined, magnesium-reduced, and sodium-reduced metal points to considerable variation between the three types.

Electrorefined titanium shows a Brinnell hardness of 66 to 81; the sodium-reduced metal averages 98; and the magnesium-reduced, 120; and tensile properties of the annealed metal are linear functions of Brinnell hardness. Bureau metallurgists J. D. Ramsdell and E. D. Hull say the 66-Bhn material shows a tensile strength, before cold working, of less than 40,000 psi; the 120-Bhn material, about 60,000. After 40% reduction, the tensile strength of the softer material is about 80,000; of the harder material, well above 100,000.

Free copies of the 15-page report (RI-5656) are available from Publications Distribution Section, US Bureau of Mines, 4800 Forbes Ave, Pittsburgh 13.

New polymers to conduct electricity

Resins that serve as charge-carriers when dissolved in non-polar organic solvents are being prepared at University College in London. An American Chemical Society report says these materials may even be conductive in the solid state. Thus far, though, only the dissolved materials have been tested, and they do not conduct electricity unless an acid is present. Work is continuing, both on production methods and on the conductive mechanism.

High-speed electronic flash has no afterglow

An electronic flash which achieves and maintains peak brilliance instantaneously, and then shuts off without afterglow, is helping Naval Ordnance Lab study and record airflow.

The device is a gaseous-discharge tube, coupled with a "transmission line" made up of a series of charged capacitors. When the capacitors are discharged, says NOL, "alternating current races first back and then forth through the line, keeping the tube's arc burning evenly for 0.003 sec. The light then abruptly ceases to shine without any afterglow."

In addition to avoiding double exposures and uneven exposures, the device gives more light than the standard flash—about 10 times as much, NOL says.

briefs . . .

Superconducting temperatures of transition-metal alloys can be markedly lowered by small alloying additions, Bell Labs researchers report. In a communication to the *Physical Review*, they note that previous studies showed small amounts of rare-earth elements had a major effect on several transition metals (titanium, columbium, vanadium). Now, tests of a molybdenum-rhenium alloy indicate that a "drastic lowering" of superconducting temperature occurs when small amounts of iron are added. The importance: such findings pave the way for "engineered" alloys for electrical and electronic components, also add to basic knowledge of superconductivity.

Liquid neon (boiling point: —410 F; price $250/qt) is now being shipped by The Linde Co from its Tonawanda plant. It's much too costly for general commercial use, of course, but Linde believes the pioneer shipment—of a 13-qt order—will pave the way for new research uses and for such special product applications as cryogenic instruments. —ARG

New combination-meter for the lab

A transistorized frequency meter and chronometer, said to have an exceptionally high input impedance and to be specially designed for easy reading, is being introduced by Southern Instruments Ltd of Surrey, England. Frequency-measurement range is 0.1 cycles to 120 kc/sec, accuracy 0.005%, input impedance 10 megohms (below 2 v rms input level). Counting period and display time are both adjustable over a wide range, and a latching system is provided to retain the previous count while a new one is being made.

The unit operates on standard voltages, measures 10 by 13 by 11¼ in., weighs approximately 20 lb, consumes about 45 watts.

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DEVELOPMENTS TO WATCH...

Diffusion-bonded coatings are key to new joining process

Copper components can be joined with a homogeneous bond which is "as strong as or stronger than the base metal," says Chase Brass & Copper. It's done by using a special coating on the metal; the coating diffuses into the parts being joined and produces a bond without an interforce. The joints, Chase claims, have high thermal and electrical properties, good corrosion resistance, and low porosity.

The coating can be applied either to semifinished mill products or to fabricated parts and requires "only reasonable care in handling." It is diffusion-bonded at 1700 to 1800 F in hydrogen. This, of course, anneals the base metal, and may limit applications to some extent. Furthermore, the process—insofar as diffusion bonding is concerned—seems limited to high-copper, low-zinc alloys; though braze-type joints have been achieved in brasses containing as much as 30% zinc.

The process is still in the R & D stage, but samples are available for evaluation and Chase is preparing to produce and market precoated copper strip.

Improved thermistors may replace thermocouples

Thermistors with higher temperature coefficients of resistance, improved electrical and structural stability, and better chemical resistance are being developed, says R. W. Smith of AC Spark Plug, and the new compositions may be able to compete with thermocouples in the high-temperature field. Furthermore, he says, it should be possible to produce materials with positive rather than negative temperature coefficients over limited but controllable ranges.

Much remains to be learned about the ceramic materials used for thermistors, and the effect of such factors as chemical composition, heat treatment, particle-size distribution, and sintering atmospheres on the properties of the finished product. But work in these areas is now in progress, and the outlook is decidedly encouraging.

Navy replacing nitrile rubber-cork gaskets

In piping systems—for aircraft fuel, air, steam, and sea water—the Navy's Bureau of Ships is recommending replacement of gaskets (MIL-G-6183) made from cork and Buna N acrylonitrile rubber (SBN) with sheet rubber (where temperature is not above 150 F) or asbestos sheeting. The reason: the previously used material "is by nature very soft and as a result is frequently over-compressed." Permanent set and loss of resilience occur when the rubber is compressed beyond 40% of its thickness.

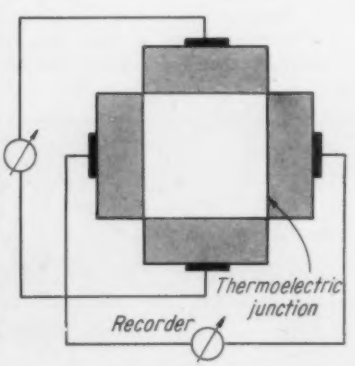
The change in gaskets may also require a change in bolting, BuShips notes. Where "hard" asbestos gasketing (sheet less than $\frac{1}{8}$ in. thick) is used, steel bolting (or bolting of comparable yield strength) is indicated.

In class A bolts and class A and B nuts, K-Monel will be substituted for Monel.

Thermoelectric analyzer measures motion

A thermoelectric device that measures and records movement without direct attachment to the moving object is described in a Czech patent (91,741), assigned to Vladimir Valter.

A heat-producing light source is attached to the moving object. An optical system picks up this light and concentrates it on the central metal plate of the thermoelectric unit (see diagram). The voltage generated as the light trace moves then indicates position and direction of motion.



THERMOELECTRIC CELLS formed by junctions between central metal plate and surrounding strips generate a voltage proportional to the distance between light source and contact plane.

New system improves mica insulation

Greater electrical and mechanical strength and less waste of materials are among advantages claimed by Siemens of West Germany for a new insulating system based on electrophoretic techniques. Starting point is a mica "pulp," said to have unusually good bonding action—so good, as a matter of fact, that the mica will even spread to cover adjacent segments. The system is now under test for commutators and slip rings.

Noise serves as tipoff to mill operation

Noise-level measurements indicate ball mill performance in a new system designed by Elliott Brothers of London. The method is based on the fact that the noise level within a grinding mill is related both to loading and to particle size. Thus, by monitoring the noise level, it is possible to follow the progress of the grinding operation and sound an alarm when deviations from a predetermined standard occur. The Elliott unit compensates for extraneous noise and takes into account the decrease in interior noise level with decreasing particle size.

New rotary switch offers longer life, rugged construction

A rotary switch "devoid of friction" and with "a longer rated life than any previously produced" is claimed by Hathaway Instruments of Denver.

Two gold-plated magnetic wires suspended in a nitrogen-filled glass bulb serve as the operating mechanism. When a "V" magnet is brought into contact with the bulb, one pole adjacent to each wire, the wires assume opposite polarities and move together, closing the switch. The strong magnetic force, Hathaway says, makes the switch extremely resistant to vibration, and the hermetically sealed cantilever design is especially adaptable to miniaturization. The individual switch sections are 1½ in. long, and can be stacked on a common shaft, on which the magnets are mounted. A signal commutator using the same basic structure is now being designed.

Linear polyethylene heads for higher temperatures

A new route to heat-resistant polyethylene is reported by Esso Research & Engineering. This is a combination of chemical-irradiation techniques in which the resin is first mixed with an aromatic hydrocarbon and then subjected to high-energy radiation. The resulting material, Esso says, has a melting point of "above 400 F"—more than twice as high as the original material. A full description may be found in British patent 840,070.

Modified titanium alloy proves out in ordnance

A modified version of the popular titanium-4 aluminum-4 vanadium alloy is proving its ability to achieve strengths in the 160,000 to 190,000-range with an elongation of 7 to 8%, Crucible Steel reports. But, Crucible cautions, heat treatment is just about as important as composition for maximum benefit. Says Crucible: "The amount of hot work, the temperature of working, and the final heat treatment are all important variables." In forging, reductions of 50% in hot working are desirable, with a forging temperature of 1625 to 1700 F, followed by a water quench, soaking (at 1630 F), quenching, aging (at 1100 F) and aircooling. Composition of the modified titanium alloy is 6Al-6V-2Sn.

French design computer for engineering

A desk-size engineering computer that operates on standard current (220 v), without air conditioning, is to be "mass produced" by Societe Le Materiel Electrique and Societe d'Optique et de Mecanique of France.

The units measures 70 x 35 x 33 in., consumes less than 2 kva, has typewriter input and output, with a normal speed of 10 characters/sec that can reach 46 to 50 characters/sec with an auxiliary ribbon perforator and photoelectric reader.

It has a magnetic drum memory (16,384 "words" of 33 binary signs each), and a ferrite-torus fast memory with 16 registers.

A new model with a capacity of 10 million characters is now under development, and should soon reach commercial production. —ARG

FROM WASHINGTON . . .

Federal R & D spending in fiscal '62 to pass $9.4 billion

Federal spending on research and development rises to $9.4 billion in the fiscal 1962 budget. This is a $770-million increase over the present year, and a $1.7 billion jump from the 1960 budget.

Some 75%–$7.4 billion–goes for national security programs, with Dept of Defense accounting for $4.8 billion. The Atomic Energy Commission takes the next largest chunk of military R & D money, some $891 million.

National Aeronautic and Space Administration leads federal R & D spending for the so-called nonmilitary program, with some $967 million. Next on this front is some $483.8 million to go mainly for federal medical research.

Basic research is slated for about $1 billion, up some $200 million from the current year. Some $375 million of this billion will be doled out by the NASA for its space programs. About $44 million will go for engineering and hardware costs of NASA's satellite and rocket programs.

National Bureau of Standards gets a healthy boost in funds from $44.3 million this year to $77 million in the new budget. In addition, some $953,000 for research and technical services will be sought in a supplemental request. Largest chunk of the added money–$50 million–is for construction of new facilities for NBS. A $5.2-million increase is earmarked for research and technical services, however, for a total of $24 million.

Work in the fields of physics and electronics takes $8.8 million of this bureau's research money; mechanics and engineering is increased some $432,000 to $2.5 million; and chemistry and metallurgy will get $4.8 million, up $618,000.

For the first time, Bureau of Standards has been allotted foreign currency money for contracting of research overseas. A fund of $1 million has been included in the 1962 budget.

Military research calls for some $584 million for space projects. This is an increase of $73 million over the current year. The money will go for continued development of the Air Force's Samos, Midas and Discoverer intelligence satellites; the Navy's Transit navigation satellite; and the Army's communication satellite Advent.

Healthy chunks of money, too, will be pumped into development of the Air Force's Mach-3 B-70 program–about $400 million, up $135 million over this year. And the new supersonic cargo aircraft will get around $60 million, about double this year's effort.

Civil space programs under NASA in 1962 are slated for $1.1 billion (a supplemental request will go to Congress for $49.6 million for 1961 programs). And industry will be asked to contribute some $10 million in 1962 for communication-satellite programs. This makes a net increase for the agency of some $155 million.

By and large, the NASA budget reflects a slight downturn in requirements for new facilities at its research centers around the country; a sharp drop-off–over 50%–in tracking-facility requirements; and a tapering-off in such projects as the man-in-space Mercury program, and development programs of the Scout, Delta and Centaur boosters.

Less than 15% of NASA money goes to in-house projects. The balance is channeled directly by NASA or through the military to industry. Development of the big 1.5-million-lb-thrust Saturn boosters is earmarked for some $250 million, almost 25% of NASA's total budget for 1962. It is a $20-million increase over the present year, but still not the peak spending period for this booster stated to be operational in 1964-65.

Some $68.6 million will go for developing an active communication-satellite system. And some $29.5 million for NASA's long range man-to-the-moon project Apollo program. The balance of NASA's money goes for the score or more of space programs it now has underway.

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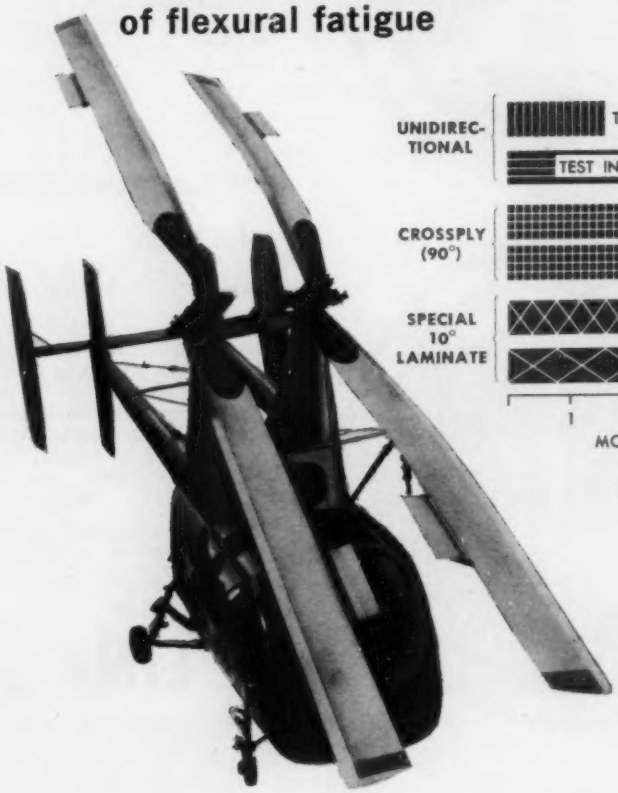
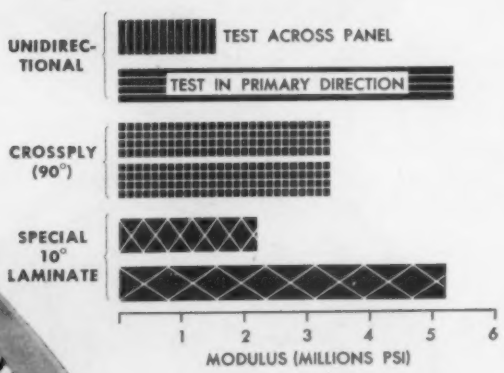
Modulus of elasticity taken in the lengthwise direction and crosswise direction for several laminate orientations are shown at right. Any intermediate ratios may be obtained as "SCOTCHPLY" can be tailored to meet specific stress requirements.





Cross-hatching indicates filament orientation

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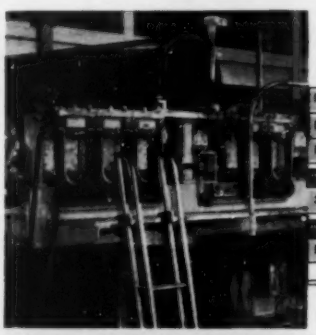
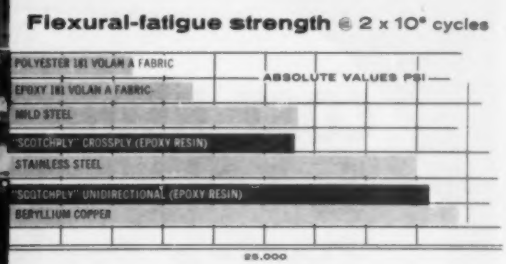
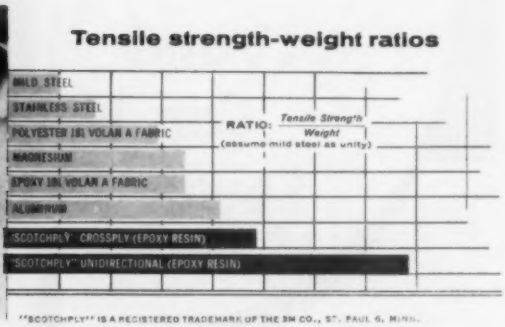


FLEXURAL FATIGUE failure of metal Fourdrinier springs resulted in costly breakdowns on this paper machine manufactured by Rice Barton Corporation. Now Fourdrinier springs of "SCOTCHPLY"—tailored to the application—do the job.



EXTREMELY HIGH TENSILE STRENGTH and light weight are essential in this battery case by Prewitt Aircraft for a classified missile. By proper orientation of reinforcing filaments, "SCOTCHPLY" provides maximum strength where strength is needed to withstand tremendous acceleration loads.



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THE ENGINEERING WEEK

Sloan Foundation Gives Samples of Its Research Aid

NEW YORK—Basic-research grants by the Alfred P Sloan Foundation have now reached $1 million a year. Total volume of annual grants has been rising about $200,000 yearly since the foundation began supporting research in 1955. And by now nearly 500 scientists have obtained unrestricted funds for research, according to a report released by the foundation's president, A. P. Sloan.

He notes that it is difficult to discuss the significance of basic studies. Aside from the specialized character of most work undertaken by Sloan fellows, its value may not be fully appreciated for several years.

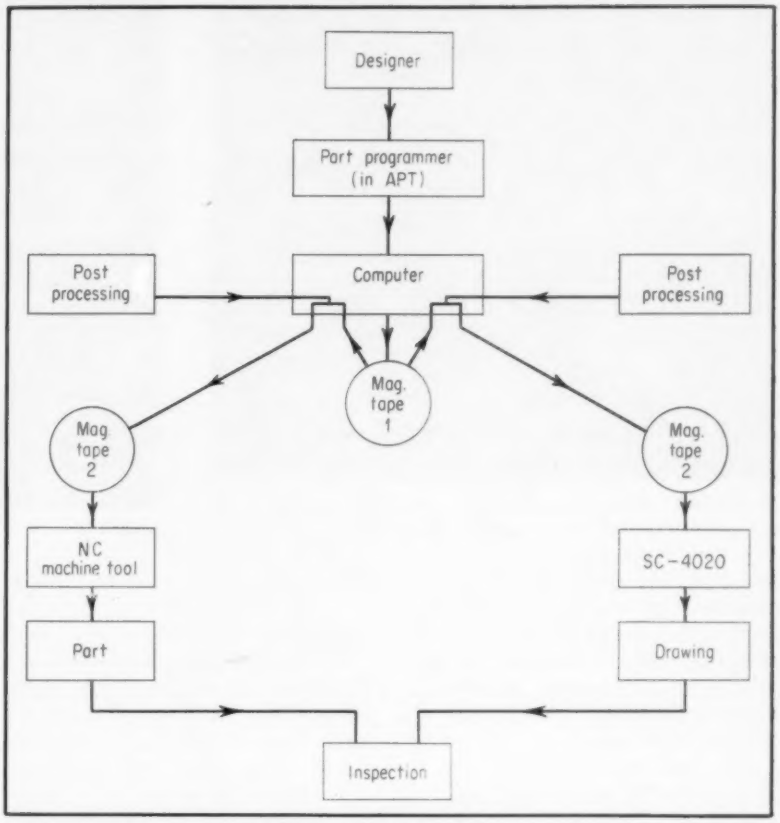
Many of the fellows are concentrating on studies of atomic nuclei and the solid state. One fellow, Dr Murray Gell-Mann, is attempting a unified theory to describe behavior of the 30 elementary particles identified in the atomic nuclei.

Dr Frank Press, a seismologist, has conceived a theoretical explanation of shock waves in the earth that may explain formation of mineral deposits and aid in detection of underground nuclear explosions. Press regards the solid earth as a "bowl of jelly" in formulating his shock-wave theories.

Imperfect crystalline lattices, which are known to have an important bearing on electrical and mechanical properties of solids, are under investigation by Dr. Charles P. Slichter, among others. He is examining self-diffusion of atoms in solid aluminum and similar metals. His experimental evidence is providing support for the theory of superconductivity, and now makes it possible to predict which substances will be superconductive (i.e. produce no resistance to flow of electricity).

Fellows in astronomy are attending to such problems as gamma- and cosmic-ray flux in an attempt to explain the origin and decay of matter, and the mechanism of absorption and generation of radio waves from outer space.

The foundation's policy, Sloan says, is to give direct support to men and women working in educational institution. ■

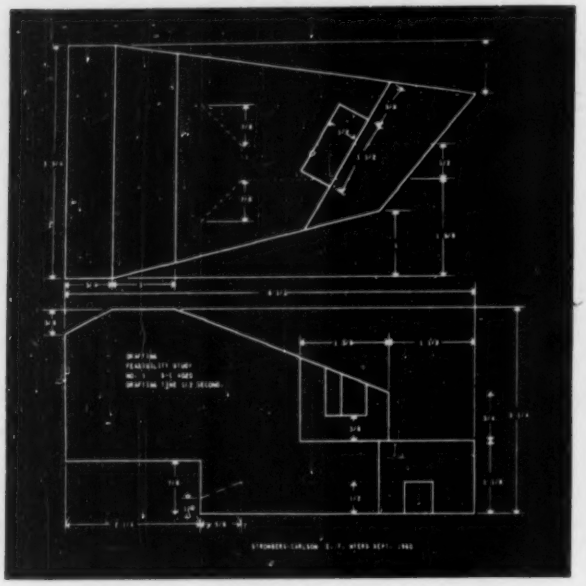


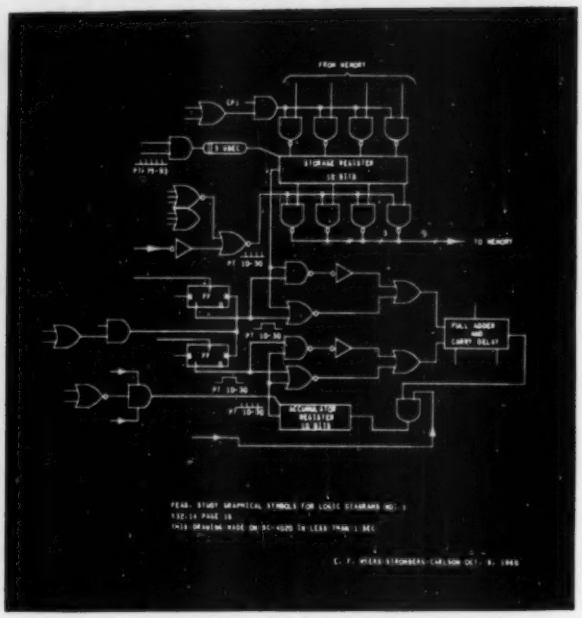
DESIGNER COMPLETES CONCEPTUAL DESIGN which is put into numerical form so part programer can convert sketch into Automatic Programing Tool System (APT) language. Programer converts the part configuration into algebraic forms and puts it into computer format. Computer calculates the tool cutting path and produces a magnetic tape. This tape (No. 1) which is in standard format, is passed through a post-processing routine to convert the general information into specific data on tape No. 2 for the particular machine control system. A second post-processing routine programs the SC-4020 high-speed printer. As the drawing is made automatically from the same input information as the machine-tool tape, the print can check the tapes for gross errors in part shape or dimension, and gives inspection a print to use immediately in checking parts being manufactured.

Numerically Controlled Draftsman Makes Its Bow

SAN DIEGO, CALIF—An "automated draftsman"—really an adaption of the S-C 4020 high-speed microfilm printer—has been developed by Stromberg-Carlson Div, General Dynamics, here. It produces "drawings" or "block diagrams" in fractions of a second, operating as peripheral equipment handling the output from large-scale digital computers. Output is recorded on 35-mm film in the form of plotted curves, tabular data or alphanumerical printing; can be printed by xerography or projected on a screen within 8 sec (see cover).

The equipment is limited by the necessity of working with large-scale computers, but "draws" from the tape developed for numerical control of machining, with a few added directions to cover legends and dimensions. One local aircraft company estimates its costs for drawings to check numerical-control tapes is about $50,000 a month; another estimates the new unit could cut the manual labor in drawing 40%. In one test, a draftsman with some background in an-





IN LESS THAN A SECOND for each, this part drawing and block diagram were reproduced from the original 35-mm "tracings."

alytical geometry was trained to program the setup in less than a month. Cost is expected to be $5000 per month for rental, or about $250,000 for purchase, depending upon whether a projector is included with the original equipment purchase.

The unit in its present form is 60 in. high, 29 in. deep, by 66 in. long (or 88 in. with automatic-processing camera-projector or tape-input unit). It has much greater speed than would normally be required, being able to record data at 15,000 characters per sec, or plot graphs at 15,000 points per sec. Cost can presumably be lowered considerably with slower-speed elements planned.

Heart of the device is a Charactron shaped-beam cathode-ray tube, with resolution about four times that of a TV tube. It can superimpose corner boxes, bills of materials, business forms and the like on the film, eliminating printing of such forms, can simulate typing, can work on-line or off-line with the computer, can generate axes, solve equations, draw straight lines extremely accurately between any two points. It can also eventually draw cross-sections at any desired plane through the plotted object or draw a cabinet projection of it at any desired angle of rotation, with special instructions fed in by the computer.

SEQUENCE OF OPERATIONS

The engineer's rough sketches or calculations are programed, either by the engineer or a programer, and put through the computer in the normal way to produce a numerical-control tape. Two tapes can be produced, one to guide the machine tool, the duplicate to make the drawing. There are no special instructions for the printer except to "draw" double-weight lines or to put arrows and dotted lines for dimensions and the like. ■

England Wooing Germany into International Space Program

BONN—West Germany is taking a hard look at the British-sponsored proposal for a joint European and Commonwealth space program (*PE*—Oct 17 '60, *p* 15) that was sketched out last month at a 10-nation meeting in Geneva.

UK's Minister of Aviation Thorneycroft is meeting here this week with West German Foreign Minister Von Brentano, Atomics Minister Balke and Defense Minister Strauss, with hopes of winning a German commitment to participate in the international satellite effort that Britain would like to build around its Blue Streak rocket. And next week a West Germany technical mission, along with similar groups from other European countries and Canada, will go to the UK for a briefing on the Blue Streak and its possible use as a launching vehicle for a communications satellite or other space-type probe vehicle.

WEST GERMANY INTERESTED

Bonn sources stress that West Germany is definitely interested in getting into space activities. But its government is not yet sure that the British plan is the way, because of uncertainties over the plan's real goals. For example, Germany wants to steer clear of any space project with a military overtone. And the government considers economically foolish any space effort that would put Germany into competition with already well-established American and British rocket and missile enterprises. Thorneycroft's visit is aimed chiefly at clearing up these uncertainties and to get a space program going.

Though he may succeed in this, another hurdle must be overcome before Bonn can join the international project. At the moment it is not clear just which federal ministry or agency has jurisdiction over space affairs. That has yet to be established by the West German Cabinet. ■

Missile Planners Charged with Neglecting Commercial Aviation's R & D Needs

WASHINGTON — President Kennedy was told last week that the nation's plane programs are suffering because of overstress on the space efforts. This diagnosis came in a special report by a 9-member committee under chairmanship of Dr Jerome B. Wiesner, director of MIT's electronics research lab and newly designated White House science adviser. The special committee blasted at the lack of effective leadership coming from the National Aeronautics and Space Administration and the space empire-building going on within the three military services.

Specifically, Wiesner's group criticized NASA for pumping too much of its research into what is known as in-house facilities. And it scolded the space agency for neglecting its responsibility to conduct aeronautical research in aviation—a failure, the report states, that may well see the Russians and British outpace the US in development of supersonic commercial aircraft. In fact, the committee suggests it may be better to turn over this research to another government agency or go outside of government to have it done.

FURTHER RECOMMENDATIONS

To take advantage of the bigger payloads that will be lofted into space when large-thrust rockets engines are developed, the task group calls for the immediate initiation of a research program in advanced instrumentation.

Duplication of efforts and the failure to provide back-up booster development were singled out by the committee.

To overcome the ills of the space program, Wiesner's committee recommended that: top management control be placed with the National Space Council; all military space programs be brought under one management in the Pentagon; "technically competent" people be placed in charge of NASA's key departments; and on organization be created within the government to administer an industry-government cooperative space program.

Working with Dr Wiesner on the report were: Trevor Gardner, president of Hycon Mfg Co; Donald F. Hornig, chairman, Dept of Chemistry, Princeton Univ; Edwin H. Land, president, Polaroid Corp, and his assistant, Harry A. Watters; Edward M. Pucell, professor of physics, Harvard Univ; Bruno B. Rossi, professor of physics, MIT; Kenneth E. Belieu and Max Lehrer of the Senate Committee on Aeronautics and Space Sciences.

—Seth Payne, Washington Bureau

Duplex Nickel Plating Emerges a Winner in Car-corrosion Survey

DETROIT—Environmental tests conducted by Chrysler engineers into the extent of corrosion on decorative automobile parts reveal:

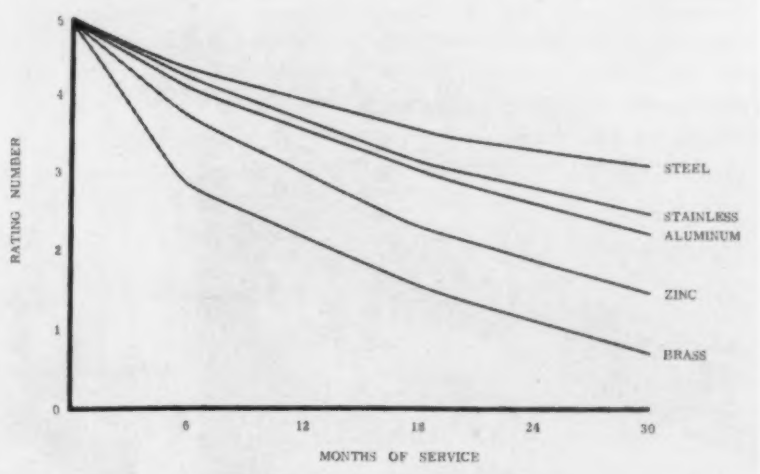
- Duplex nickel on steel and zinc diecastings extends the service life of these parts
- Type 430 stainless steel used for decorative trim should be chromium plated to avoid corrosion
- Higher percentages of aluminum in the alloy improve corrosion resistance of anodized aluminum parts.

Testing of corrosion resistance is normally done in the laboratory where prepared panels or parts are evaluated. Data are used to determine if a new plating process is as good as processes already in use. But Chrysler is convinced that the true test is the performance of the part in service. It therefore relies on surveying cars which have been in service for various lengths of time to determine performance of plated parts.

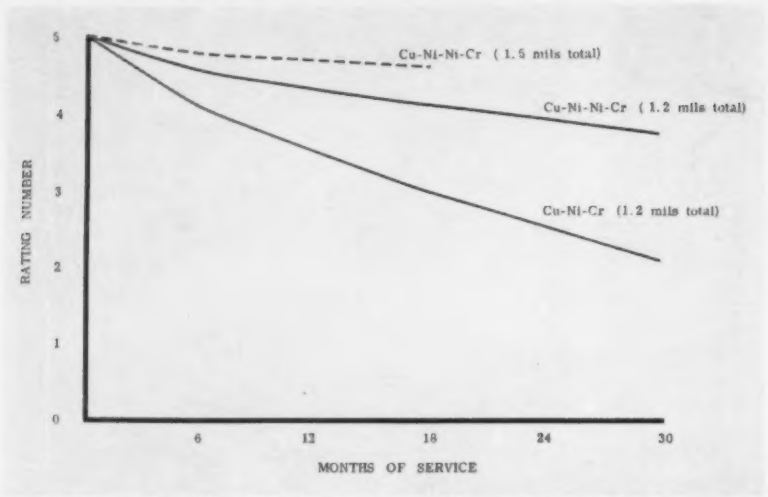
These surveys are being conducted in the Detroit area where the environment is considered one of the most corrosive in the US. This is so, especially during the winter months when moisture condenses on the decorative parts and remains for extended periods with little or no evaporation, holding dirt, de-icing salts, and other corrosive products such as ash and sulfurous acid and other byproducts from the burning of coal.

The most recent study was made last spring with more than 1500 cars inspected under the same system of rating developed by ASTM Committee B-8, described in the annual report of this committee in 1953, and first used for the car survey conducted in 1957.

A part rated as excellent is one in



DETERIORATION OF DECORATIVE TRIM with length of service. Steel line represents chrome-plated steel parts on the exterior of cars. Other lines: stainless—parts of unplated Type 430 stainless steel; aluminum—parts made of anodized aluminum; zinc—chromium-plated zinc diecastings on car exteriors; brass—chromium-plated brass parts. Much of the plated steel decorative trim on these '58-Model cars was plated with duplex nickel and chromium. After 30 months' service the plated steel trim is still acceptable. Zinc parts were plated with copper, bright nickel and chromium to a total thickness of 1.2 mils. Only two parts (the mirror-back and the radio antenna) were made of nickel-chromium plated brass.



CORROSION EVALUATION of chromium-plated zinc diecastings shows clear superiority of duplex nickel over bright nickel. Perforated line is service performance data for 18 months of diecastings plated with copper-duplex-nickel-chromium to total plate thickness of 1.5 mils. However, no data are available yet on performance up to 30 months' service. Trend established by the 6- and 18-month inspection data shows increased plating thickness is definitely beneficial.

perfect or near perfect condition and having an ASTM equivalent rating of over 9.5; a part is rated good with an ASTM equivalent of 8.5 to 9.5; a part rated fair has deteriorated to an ASTM rating of 7.0 to 8.5 and is considered borderline; a part rated poor is unacceptable; its ASTM equivalent rating is less than 7.0. In the graphs on page 17 and above, these classifications have been translated to numbers—excellent, good, fair and poor relate to 5, 4, 2 and 0 respectively.

Inspection personnel were experienced in matters of corrosion, but to ensure that each inspector gave the same rating to a part, a number of cars were inspected and the ratings compared. If differences in ratings occurred, the parts were reinspected. This reinspection procedure was repeated on different automobiles until these differences were reconciled. In only a few instances was reinspection necessary.

—Felix Giordano, Regional Editor

Manned Shot in March If Monkey Makes It

WASHINGTON—Early in March, the US may send its first astronaut into suborbital flight from Cape Canaveral. That is what the National Aeronautics and Space Administration is predicting privately.

The manned-flight attempt will depend on results from a similar test in the Project Mercury man-in-space program this month. A chimpanzee is slated to ride in a Mercury capsule some 100 mi high and down-range about 200 mi. Known as test MR-2, it's another in the series of tests of the Mercury capsule planned to carry a man into space and back before '62.

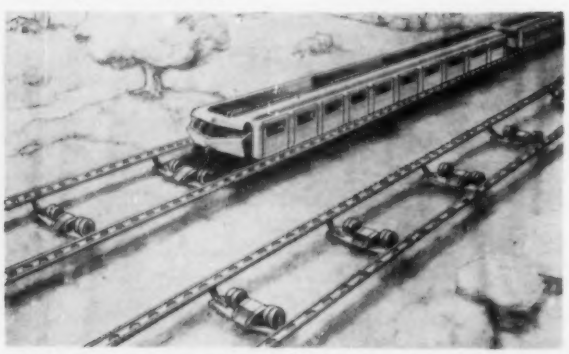
A few weeks ago, NASA successfully shot a Mercury capsule some 135 mi into space and 235 mi down-range. This was test shot MR-1. It followed a series of mishaps in previous test shots of the Mercury capsule.

The success of the MR-1 shot moved the man-in-space program to its next milestone, that of sending a chimpanzee into suborbital flight. If all goes well on this test, then an astronaut will likely be lofted into space in early March.

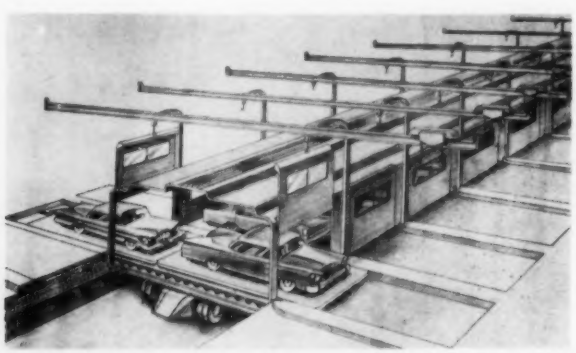
It will be the first of several suborbital flights planned for the astronauts before an orbital flight is attempted. While the program proceeds with the manned high-altitude testing, unmanned orbital flights of the capsule using the powerful Atlas booster will begin.

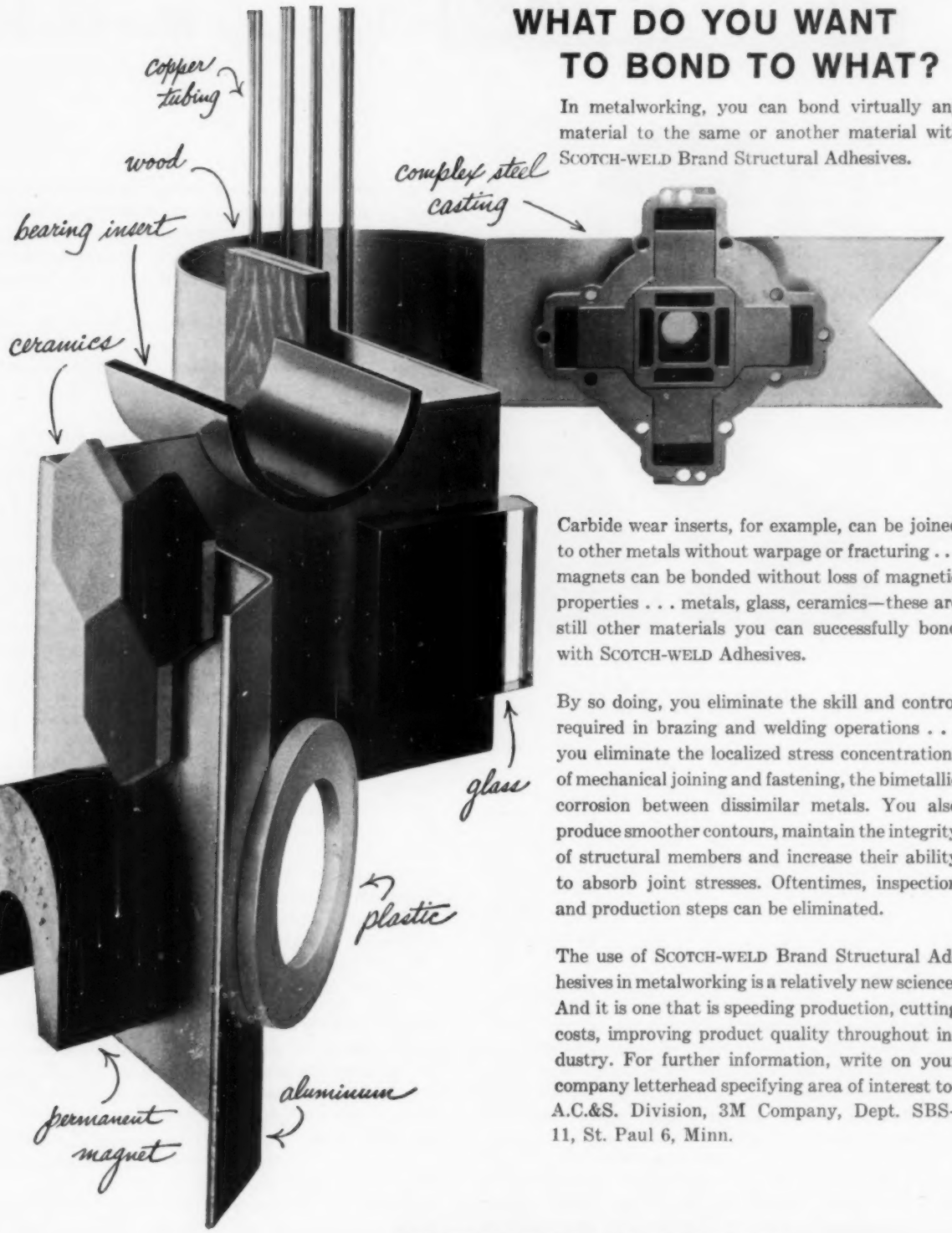
—Seth Payne, Regional Editor

Tomorrow's Highway—Automatic and Up to 150 Mph



This high-speed computer-controlled electric highway proposed by Westinghouse Electric Corp would transport cars at speeds up to 150 mph in open areas and at urban speeds up to 75 mph. Flat-bottomed carriers, passed along by electrically driven rubber wheels spaced about 20 ft apart, would be guided by tracks on both sides. The wheels, in addition to serving as the highway surface, would accelerate the conveyances, keep them moving once accelerated, and give breaking power at proper locations. Westinghouse engineers say each lane of the highway would be a continuous, computer-controlled system of individually powered rollers, receiving electric energy from neighboring interconnected electric utilities. The train of carriers (3 to 10 units, each) would be stopped at fixed stations for automatic loading and unloading of cars (above, right). Drive package for each roller would consist of a 3-phase induction motor, torque converter, brake and reduction gear.





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3M COMPANY

POINTS OF VIEW

THE QUESTION: *How Do You*

John R Parker
Vice-president
Automotive and Railway Products
A O Smith Corp, Milwaukee

Integrate is the key word. Traditionally there are several functions—such as design, tooling, manufacturing, inspection—that bear on the ultimate delivery of a satisfactory product to a customer in the required quantities and at a competitive price. These have been considered more or less separate, even independent functions. Supposedly each becomes operative when the other is "finished"; the very sequence of operations suggests getting the benefits of specialization. But in practice, this traditional separation of functions has to be abandoned, or at least modified. Some form of communication must be established between the functions; and the success of the operation as a whole depends largely on effectiveness of that communication.

As a case in point, our Automotive Products Div has had in operation a system that ensures communication among all the design and manufacturing functions at all stages of the operation. It involves not only our own departments, but our customers as well, in a joint effort to achieve a design development that lends itself to the most economical fabrication, consistent with high reliability, of major automotive components. This system evolved gradually. The main difference between this system and our previous efforts in the same direction is that we now have an organized method that constantly involves all of our own facilities while it maintains contact with our customers, the automotive manufacturers. It replaces a former method of calling in various departments only when difficulties arose involving them. Going beyond troubleshooting, it adds prevention; it aims at achieving early design improvements and changes; and, of course, at correcting procedures at all stages of development—in the light of manufacturing experience.

Liaison with customers

Our relation with customers is not that of being merely passive fabricators of their designs. We are active participants in the design function, which is aimed at the joint development of designs that satisfy the customers' functional requirements while also possessing characteristics of highest producibility and consistent reliability. Perhaps the best way to illustrate the effect of this system on our operation is to follow the development of a design from conception through actual production. The main link between an automotive manufacturer and us is the sales-account engineer. His is a dual function. He is the representative of our company to the customer. We also consider him the representative of the customer—advocate of the customers' interests.

In development of a new design, the sales-account engineer establishes, with our customers, the functional requirements and the general line of development of the new design, which may be based on ideas advanced by us or on a concept originating totally with the customer. This design, at the moment little more than a set of functional needs and a general configuration, is then relayed to a committee—the engineering-project team. Generally speaking, the function of this committee is to establish a satisfactory design and bring in desirable design changes at the earliest possible time.

Engineering-project team

Each major automotive customer or each major segment of business is assigned a similar committee. The team is headed by a project administrator who is completely responsible for all phases of the product from engineering, through production, to its ultimate performance. A byproduct of the team concept is the stress on quality engineering.

Besides the project administrator, each team includes a highly qualified design engineer, a planning engineer, a tool designer, a plant engineer, a process-control engineer, a manufacturing supervisor, an inspection supervisor, and a maintenance supervisor. The sales-account engineer is ex officio member of the team, and maintains close contact with it, representing the customer's aims and needs.

Integrate Design and Production?

On the basis of the customer's specifications and initial drawings, the committee develops a proposed modified design, which is submitted to the customer through the sales-account engineer. This proposal is in essence the company's version of the original basic layout, based on our experience, our manufacturing skills and on the history of our experience with previous similar designs. It reflects such different influences as ease and economy of tooling, expected production flow with minimum down-time, best materials-process and facilities utilization, ease and reliability of inspection, even economical utilization of production space. This first proposal sometimes involves design changes from the original layout. Such changes may be extensive, but in the joint opinion of our own design engineer and of the sales-account engineer, they don't compromise the functional requirements of the part.

Design changes

Normally our customer's people modify this proposal to make the design compatible with their own needs, especially to facilitate assembly and later maintenance and servicing of the finished product—in our case, an automobile. The first working model is then built, incorporating these changes. It is mounted in an automobile and performance-tested. The tests, interpreted in the light of previous experience, permit us and the customer to evaluate the adequacy of the design, to make further changes in component structure if needed, and finally to approve the design as modified.

Still, the design is not final, though it comes pretty close to the final product. Changes occurring now are relatively minor, to solve unforeseen problems that only experience with this design can bring out. By the time the design is released for production, the engineering project team has completely planned the tooling, the processes, the equipment and the operational sequences, including inspection and quality control. Through this team the history of past problems is brought to the attention of the proper engineering function, and improvements in process approach are evolved. Generally speaking, the function of the committee is to establish a satisfactory manufacturing facility and to bring in design changes which improve compatibility between manufacture and product performance.

In establishing the basic design, the engineering-project team discusses design ideas before they are crystallized, each member of the committee explains how a proposed design would affect his function, and also suggests what changes in the design would facilitate it. A number of design ideas are scrapped, changed or merged until an approach is evolved which is agreeable to all as the best compromise that can be achieved on the basis of present experience. Later design revisions, made necessary by problems that only manufacturing experience can uncover, are also made by the committee as a whole, as each manufacturing function may be affected by the change.

Our experience with this system has been that most of the difficulties normally encountered with a new design are eliminated at the start. As a result, the "going in" quality of new products has been substantially better than in previous models.

Team effort

There is only one reason for a design, and that is the ultimate production of a salable product. In our case, where our product is a component in a single manufacturer's automobile, we can sell our product only to the degree that our customer can sell his automobiles. It is our manufacturing function, reflected in our interpretation of the customer's basic design, to help our customer produce the most reliable product most economically.

These are some of the basic steps in a typical project:

- Reviewing in an advisory capacity with the Sales and Estimating Depts the materials and processes best suited for new products.
- Examining new designs to determine if they are compatible with consistent manufacturing quality.
- Developing processes to overcome customers' special problems.
- Evaluating and testing new materials, processes, and methods.
- Eliminating quality problems in the design and upgrading personnel skills.
- Establishing the most economical production methods, consistent with quality and reliability, by integrating the efforts of Design, Manufacturing, Development, Economic Evaluation, Tool Design, and other departments.

Our engineering-project team differs in two interrelated aspects from the more general idea of design-by-committee. In the first place, it is a permanent group that can be called together any time the need arises. Second, because it is a permanent group, each member of the group is identified with the final design, and is committed to make it succeed. This latter advantage may be imponderable, but is of enormous value nonetheless. As every function was consulted and its representatives actually participated in the evolution of the final design, each is on his mettle during production, especially if his advice was incorporated in the design. Even if his advice was not accepted *in toto* he understands the reason for the compromise that was finally reached; he knows it is the best that could be obtained, and therefore he has no reservations about it. Thus the personal interest of each department head is identified with success of the product.

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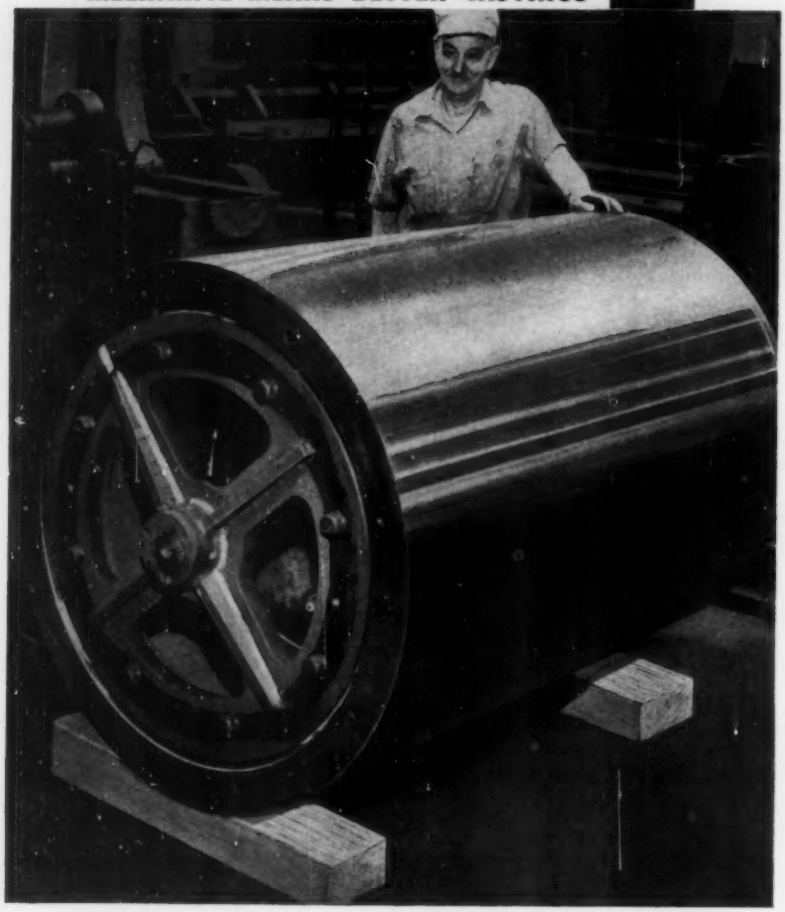

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READER TO EDITOR

Filter-media Compatibility

To the Editor:

The article on filter-media compatibility by Charles H. Hacker (Nov 28, p 29) was very interesting, but I was quite surprised by the statement that Houghto-Safe No. 620 was not compatible with carbon steel. This contradicts our experience. What is the basis for this statement?

—JOHN A MATHE
Lubrication Engineer
E F Houghton & Co, Philadelphia

• *The author replies:*

Houghto-Safe 620 contains an amount of water which would automatically make it incompatible with carbon steel, or at least give it limited compatibility with carbon steel. Very probably the last three items of page 37 of the article should have read "limited compatibility with carbon steel, compatible with all others," since it is apparent that carbon steel will not be acted upon by the chemicals themselves but only by the water present.

Engineer's Creed, Revised

To the Editor:

This is written in protest against the article in your Dec 5 issue, "What Every Engineer Should Know," by P. M. Zall. In all that has been written about engineering, I doubt if one could find so many false and unmeaning statements.

For example, the author lays great stress upon a "proper attitude." This means, he says, that the budding engineer must learn to accept gracefully his spending a lot of time on non-engineering details such as administrative paperwork. He also should think in terms of a balance among budgets, schedules, performance. Mr. Zall sums it all up by the following: "A desirable attitude then, would include know-how, know how to, and know how much."

Now of course it would be easy to dismiss the whole thing for the silly drivel it is. However, unfortunately, many employers and others who deal with engineers have an equally idiotic view of the profession. And, alas, even some engineers themselves have no better understanding.

Therefore, I would like to enter a brief rebuttal:

First of all, engineering is one of the most difficult and arduous of the professions; not four years, not eight, nor even a lifetime, is sufficient to master but a small portion of the field of knowledge. No engineer can afford to waste his time on work which properly belongs to clerks, secretaries and accountants. If he does, he is cheating his employer.

Most people, I feel sure, would hold that competence is the primary consideration in any profession. Divert the engineer's mind from his proper work and he loses competence. You don't see doctors, lawyers or dentists wasting their time on clerical duties. They are masters in their own house, and here is where the engineer falls down.

The second greatest need is knowledge on the part of the engineer as to how he

may best serve his employer or client. Odd though it may seem, few employers understand what an engineer can do for them, and even more oddly, what he can't. This is a basic weakness in the practice of all professions.

The solution seems obvious—employers must learn to deal directly with engineers, not through "administration." The engineer has an even greater responsibility, he must:

1—Refuse to accept employment except under proper conditions. For example, he should refuse to work under incompetent leadership.

2—Candidly inform the employer what he can, and cannot, do for him.

3—Reject all efforts to have him perform non-engineering services; leave all positions without prospect of professional advancement.

4—Stand up for his rights as an individual. Support brother engineers when they become victims of injustice.

—JOHN E ERB
Fair Oaks, Calif

• The author replies:

I can think of no better way to start the new year than by stirring up an argument about the professional status of Engineering. But, shucks, Mr Erb's letter doesn't allow for a rational argument. It seems less a rebuttal than an attempt to introduce opinions too deeply felt for discursive reasoning. So I shall regretfully pass up the chance for an old-fashioned donnybrook. Perhaps I could simply note that the article was intended to discuss things as they are, not as they ought to be.

COMING EVENTS

FEBRUARY

1-4 . . . . Institute of Radio Engineers, Winter Convention on Military Electronics, Biltmore Hotel, Los Angeles

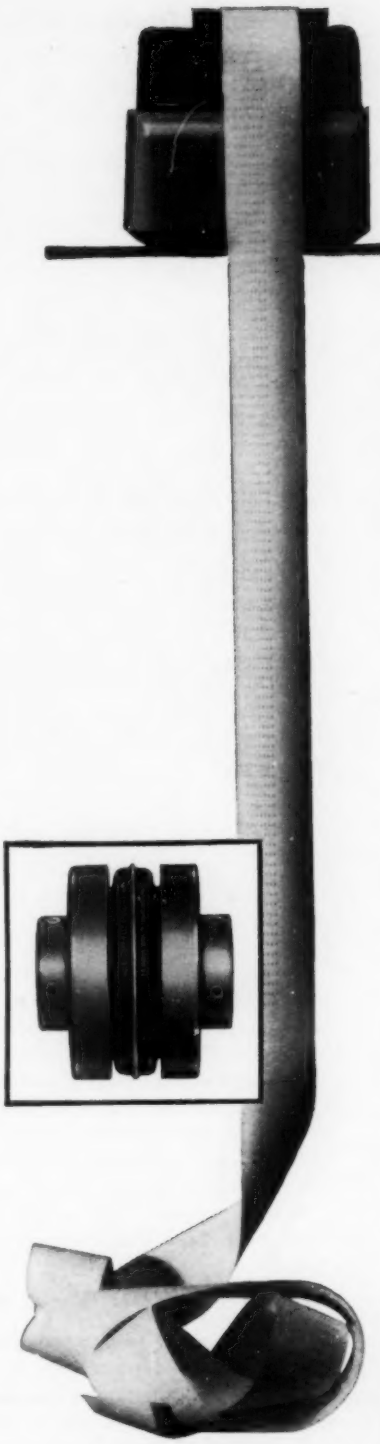
7-9 . . . . Society of the Plastics Industry, 16th Annual Technical & Management Conference, Edgewater Beach Hotel, Chicago

14-16 . . . . Society for Nondestructive Testing & Southwest Research Institute, 2nd Annual Symposium on Nondestructive Testing of Aircraft & Missile Components, Gunter Hotel, San Antonio, Texas

15-16 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, 8th Annual International Solid-State Circuits Conference. Univ of Pennsylvania & Sheraton Hotel, Philadelphia

26-March 2 . . . . American Institute of Mining, Metallurgical & Petroleum Engineers, Chase Park Plaza & Ambassador Hotels, St. Louis

For a current listing of addresses of societies and associations send 25¢ to PRODUCT ENGINEERING Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure, R 32.



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FOR YOUR INFORMATION (personal)

Doodles deluxe for the Space Age

A really complete kit for making geometric space designs in color is now available from Science Materials Center, 59 Fourth Ave, NY 3. It contains boards, rings, fasteners and colored string, to create 3-dimensional helicoids, interlocking and semicubical parabolas, and a host of other shapes. A 48-page manual tells how to hook them up, and contains a simple glossary of geometric terms. SMC calls it the *Space Geometrics Lab*, prices it at $12.95.

Controlling that "free" energy you don't want

A hundred thousand to 3 million amps of current are delivered to the earth "free" every second—but in a form we don't want and can't use: lightning.

The Lightning Protection Institute estimates that at least 100 bolts, each carrying 1000 to 360,000 amps, strike the earth every second, doing damage estimated at $100 million a year. Modern instrumentation and insulation can do much to minimize lightning's hazards. But, the Institute warns, there are "magic wand" and "atomic" devices around that are of questionable value.

A survey of protective systems plus interesting facts on lightning are contained in a fact booklet available without charge. Address LPI, 53 Jackson Blvd, Chicago 4.

Palaces of ice on the moon?

Will our space men find ice—for construction and other uses—on the moon? Quite likely yes, says Jack Green of North American Aviation.

Because the moon's gravitational attraction is too small to hold an atmosphere, it has been thought that no water or water vapor would be found there. But, Green points out, in the eternally shadowed areas of the moon the temperature is about −238 F and, at this point, the vapor pressure of ice is low enough to "admit of the possibility of the persistence of ice over geologic time." On the same basis, sulfur, too, may be found.

The significance? The importance of the water is obvious. But in addition, ice is necessary for the manufacture of rocket fuel, and sulfur can serve as a waterless cement or sealant, wire insulation, and structural material—the letter produced by briquetting sulfur with volcanic ash. Such a material, Green notes, can have a compressive strength of 5000 psi or more.

It may be a bit early to worry about making one's own rocket fuel on the lunar surface, but these ideas are worth further thought and study.

Bagpipe for skid resistance

It probably won't play a tune; but this "bagpipe" will feed grit to your car wheels; and, Koppers Co says, "provide a lifetime of safe driving, reduce wear on tires and transmission, and eliminate gas waste."

Controlled by a pushbutton on the dashboard, the unit has a vacuum valve that feeds sand or grit to the car's rear wheels through flexible plastic tubing (made of Koppers material). The complete "Skidmaster" kit, priced at $29.95, is made by Napco Industries, Minneapolis. —ARG

A cylinder doesn't think but you do—and when you turn your thoughts to how a machine can perform, a lot of things can happen.

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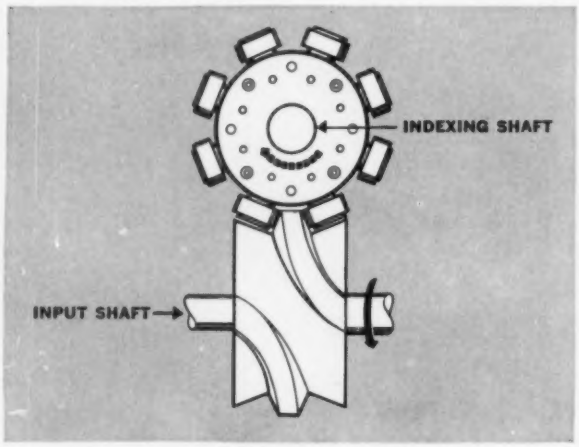
How Ferguson *ELIMINATES BACKLASH* in Index Tables

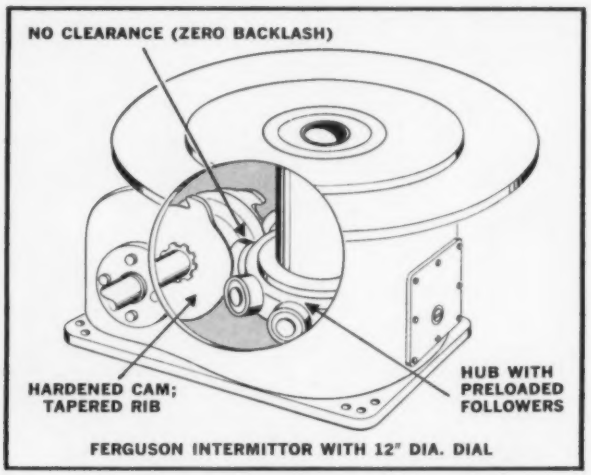
Backlash in indexing results in shock loads that affect the efficiency of a machine and the quality of its product. Most indexing mechanisms have inherent characteristics that cause backlash and poor dynamic conditions and prevent the designer from taking full advantage of modern feeds, tooling and methods that contribute to production economy.



Ferguson Intermittor Index Tables have inherent zero backlash and extreme precision which results in a rotary transfer machine base capable of operating speeds up to 500 indexes a minute. *A Ferguson index table never proves to be a limiting factor in the speed or performance of an automatic assembly machine.*

HERE'S WHY: The continuously rotating cam of a Ferguson indexing mechanism features a *tapered rib* along which two preloaded bearing followers roll, maintaining constant contact with no clearance between them and the rib. When the mechanism is in the rest, or dwell, position, a straight portion of the rib locks the followers with zero backlash and an indexing accuracy of .001". Wear on the hardened tool steel cam is infinitesimal (many have been in use for more than 25 years). Followers are rated for a minimum of 8,000 hours operation. If backlash occurs after this period the life of the drive may be renewed merely by replacing the standard followers.

NOTE HOW PRELOADED FOLLOWERS ENGAGE RIB



FERGUSON INTERMITTOR WITH 12" DIA. DIAL

Compare this with other types of indexing devices. A geneva drive, with its slotted wheel and driver, and a barrel cam with a grooved track which engages one follower at a time, must have clearance in the slot or groove to allow passage of the follower. The slightest amount of clearance causes backlash. As the slot or groove wears, the clearance becomes greater and the backlash condition worsens. At the higher, more profitable operating speeds poor dynamics cause wear on other parts of the machine. The user must choose between frequent downtime for repairs or slower speeds . . . He is the loser in either case.

FREE DESIGN DATA — Load ratings, dimensions and application and installation information about standard and stock Intermittors, Ferguson Drives and in-line machines are contained in a single 36 page catalog. Every designer should have one in his library . . . Write Ferguson—Ask for Catalog No. 160.

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PRODUCT ENGINEERING HORIZONS

JANUARY 30, 1961

THE ATTRACTIVE NUISANCES

It has been found that we, as householders, can be the owners of "attractive nuisances"—discarded iceboxes, plastic-film garment bags, unguarded swimming pools, climbable backyard structures. They attract youngsters who play on, in or with them—and may get hurt. So there are ordinances in most municipalities about them.

Modern business has them, too—the limitations that have been built by management in the name of economy, simplicity, tradition or some other real or imaginary economic idol. And Engineering too often plays the role of the youngster who gets hurt, without any ordinances, or even sympathy, to assuage the pain.

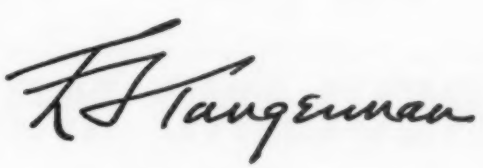
Of course there are those tender souls in Production, Purchasing and Sales who swear that it is Engineering that is normally at fault, and anything that happens to the engineers is thoroughly earned. Take the little matter of designs of assemblies and components claimed difficult or impossible to make and maintain. There have been poems—"He had, at last, designed the part that couldn't even be cast!" There have been jokes—"Next week we start designing the machine to make it." There have been curses and recriminations, coalitions and combines pledged to build real booby traps for engineers, so any "attractive nuisance" seems mild by comparison.

But let's consider the "nuisance" anyhow. The commonest is the new management "tool" that will save money. Automation, data processing, value analysis, standardization, interchangeability. All of these can and do save money, of course, but they at the same time build a very substantial Iron Curtain around design. They restrict the designer's choices, develop in him the tendency to use "all-around" parts and materials even when something special would be the right answer. They tend to build complacency and freeze development.

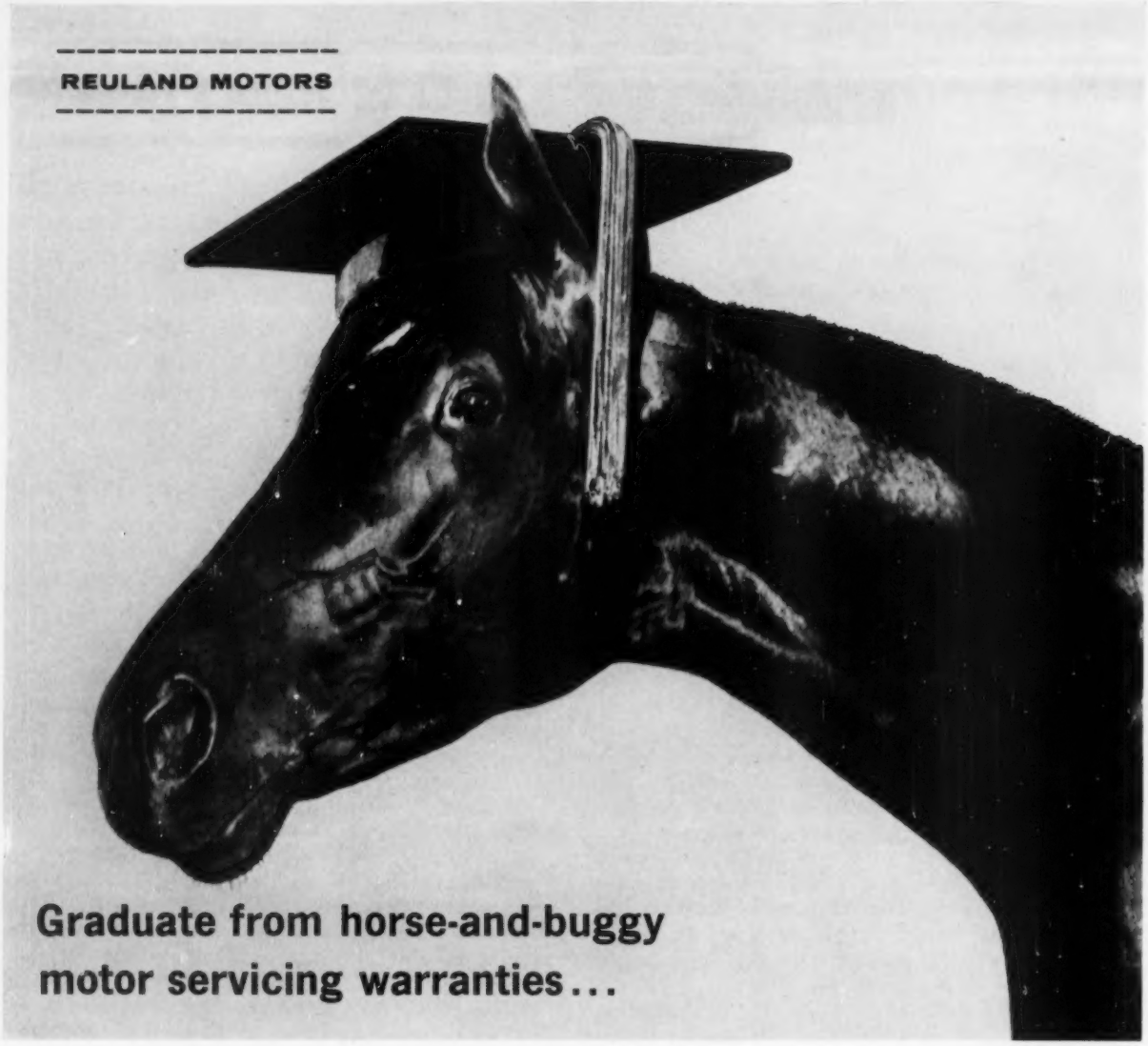
Automation, for example, demands major investments, tends to be inflexible, thus forces continued use of certain shapes and processes "until it pays for itself." Data processing involves so much programing, so many tapes and punched cards, that there's a real or intangible prohibition to introduction of new materials; "think of the cost of replacing all that painfully accumulated and costly data on inventories, cost control . . . etc, etc." Value analysis, being the cooperative stepchild of Purchasing, Production and Engineering, involves so many committee meetings, so many agreements and compromises, that there is an understandable reluctance to upset the apple cart. Standardization and interchangeability also create their limitations by hauling out the spectre of parts inventories that will never be used, multiple stocks, customer criticism, complications in record keeping, duplicate tooling costs—"let's not start that all over again!"

So the engineer wanders amid these attractive nuisances, trying to produce something new and better without battering his head on invisible fences. Touch one fence, and alarm bells ring all over the comptroller's office, every department closes ranks to surround the criminal, and the local gendarmerie and the FBI are called in.

Is it any wonder the engineer treads softly? And when he produces his "new design for economy," the pack yelps again—because he didn't "strike out into new territory."



REULAND MOTORS



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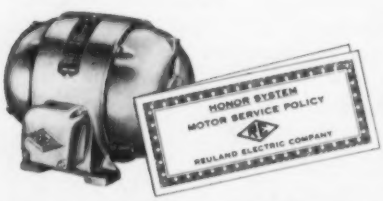

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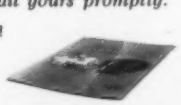

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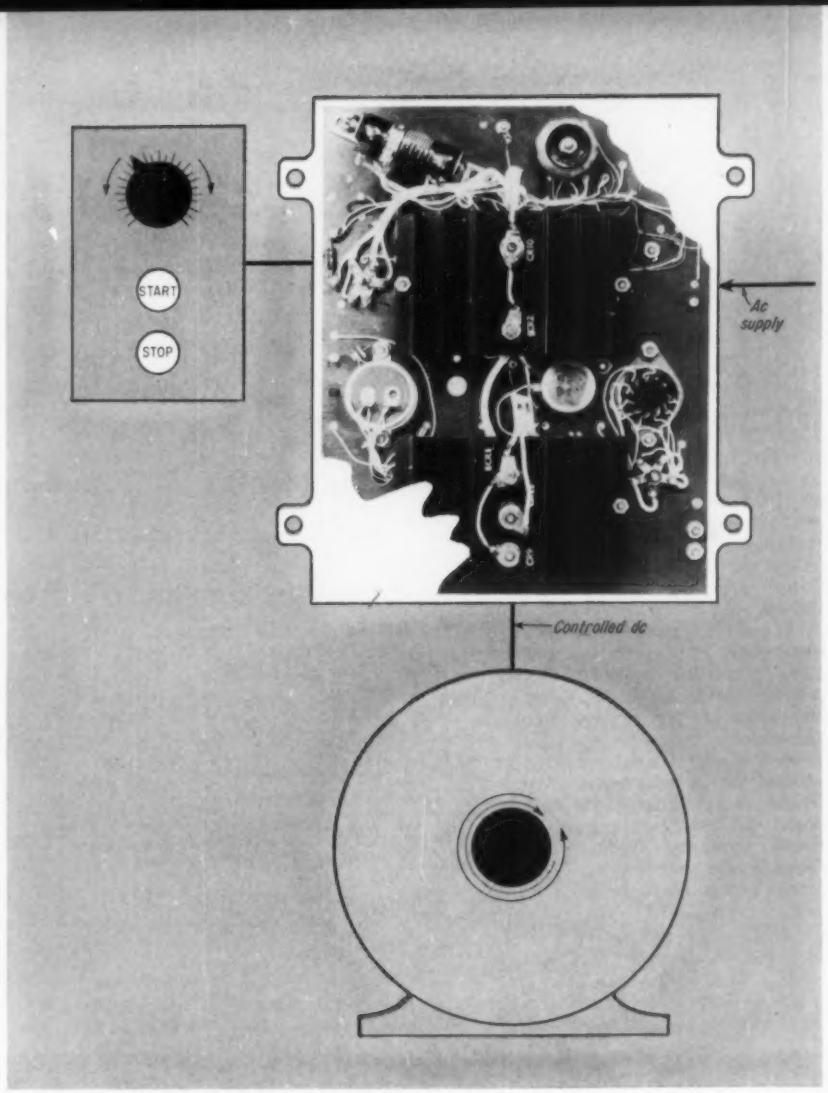


They work off ordinary line ac; they do without switchover relays

now—SEMICONDUCTORS REVERSE VARIABLE-SPEED DC MOTORS

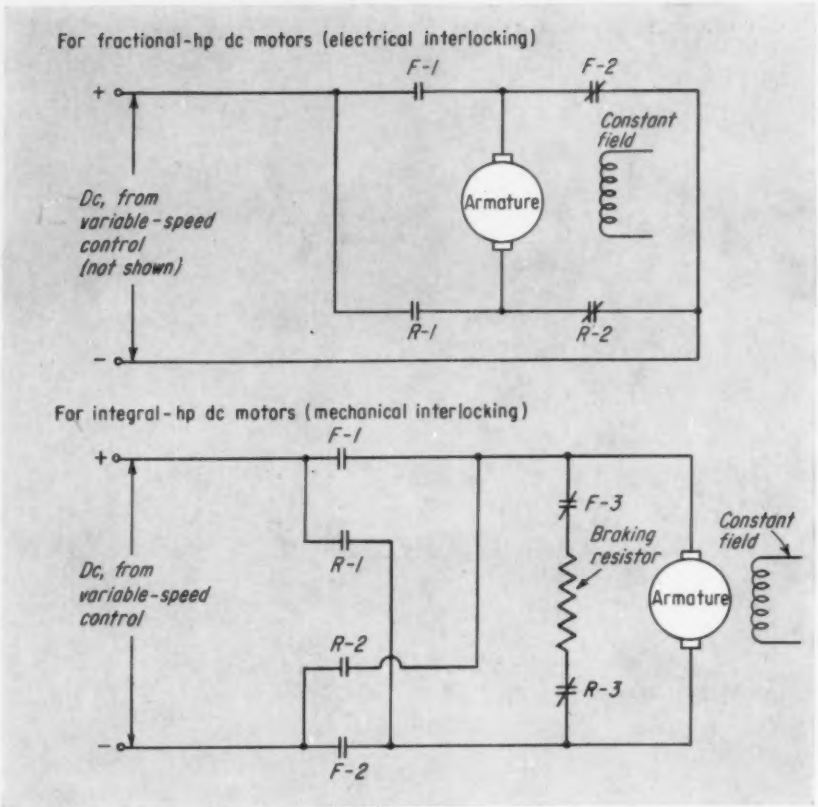
BARUCH BERMAN, chief engineer
Commercial Products Dept
ACF Electronics Div
ACF Industries Inc

A dc motor driving the worktable on a machine tool is a good example of the need for versatile control. Here, a conventional, unidirectional variable-speed drive wouldn't do. The motor has to be controlled smoothly throughout its speed range and in both directions of rotation. True, the problem can be partly solved with reversing switches or relays in series with the controller—this is the conventional way. Such switchover, however, is abrupt, and smooth control during transition is impossible.

But now we have available a "stepless" way to vary dc motor speed in full range from forward to reverse—even through zero speed. The method uses silicon controlled rectifiers arranged in back-to-back pairs. These are the tiny SCR semiconductors in the center section of the photograph at top of this page. One of the SCR's applies forward-rotation potential to the motor; the other applies reversing potential. With intentional overlapping near zero speed, full control can be maintained throughout the transition.

CONVENTIONAL REVERSAL

Unidirectional speed controls for dc motors are plentiful—the Editor's Note at end of this article lists many of them. Most are adaptable to bidirectional operation, but



CONVENTIONAL REVERSING CONTROLS depend on electromechanical relays to switch polarity of armature (speed-varying part of the unidirectional control is not shown). In both schematics, relays are in deenergized positions; motor armature is dynamically braked. Upper schematic (for small motors): motor turns forward when relay *F* is energized, and reverses when *R* is energized. Relays are electrically interlocked, but not mechanically—jarring might reverse motor. Lower schematic (for large motors): mechanical interlocking of forward and reverse relays positively prevents unintentional reversing of motor. Additional contacts (*F*-3 and *R*-3) connect dynamic-braking resistor across armature.

require switching of motor terminals at the crossover point.

Such controls usually use electromechanical relays to do the reversing of motor polarity. Two relays are needed in most instances, with safety interlocking (electrical or mechanical) to prevent "plugging" (abrupt application of full reverse potential) or short-circuiting of the controller output.

One example of electrical interlocking of relays is shown in top schematic on this page. The normally closed contacts of each relay are used to short-circuit the motor armature—giving "dynamic braking"—whenever the relays are in the deenergized position. It is impossible even with vibration or mechanical shock to short-circuit the controller because no contact can simultaneously be in two positions. However, if both relays are jarred simultaneously in opposite directions, motor will reverse instantly from forward to reverse. This will not injure small motors that have relatively little stored energy, but may be troublesome in an integral-hp motor. This design is therefore limited to fractional-hp drives.

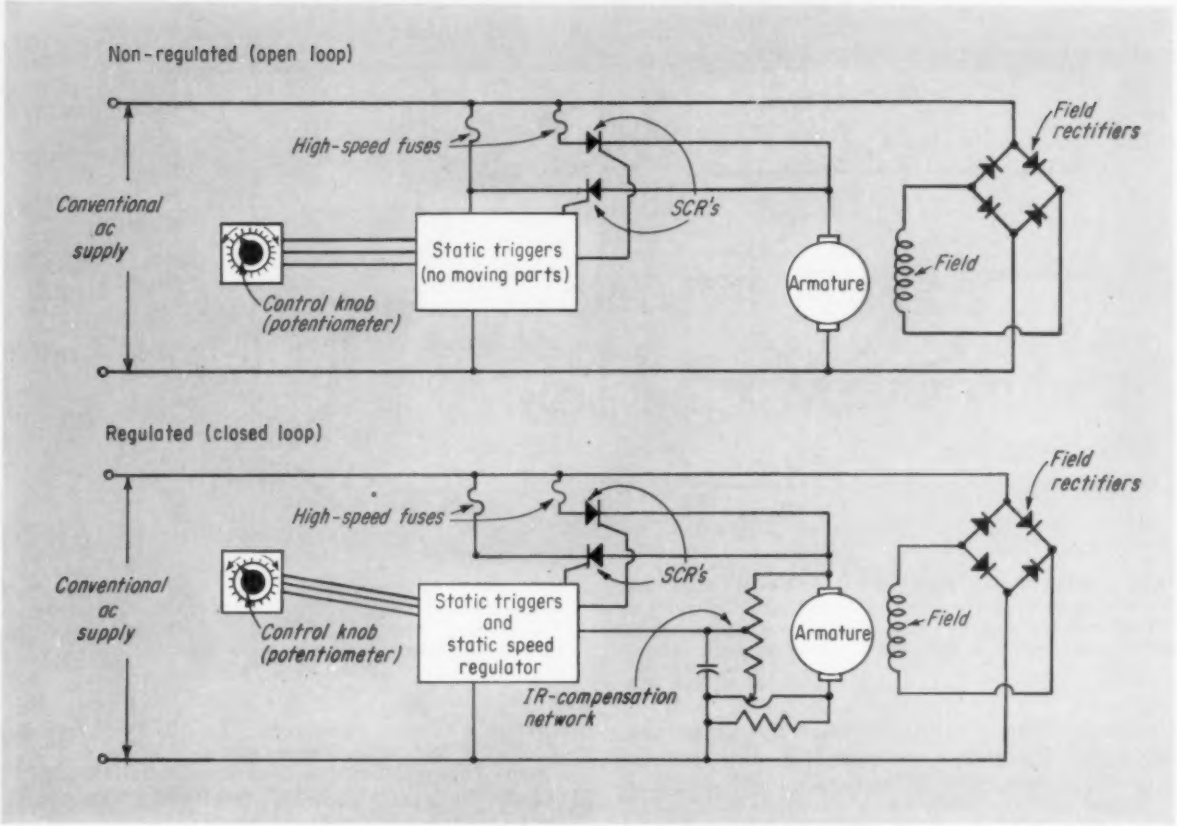
Bottom schematic shows mechanical interlocking, which adds mechanical linkages between moving contacts of two or more relays. This method is simply an extension of electrical interlocking. Here, the purpose still is to positively prevent interconnection of certain terminals. With proper linkage, contacts cannot be pushed or jarred into any undesirable positions. Integral-hp variable-speed dc motors usually have mechanical interlocking in the reversing-relay circuit to: positively connect a dynamic-braking resistor across the motor armature whenever both relays are deenergized; disconnect this resistor whenever either relay is energized; and positively lock out one relay when the other is energized.

Relay-type reversing controls are relatively noisy, and have the tendency to arc (shortening life and increasing hazard of igniting an explosive atmosphere). Another disadvantage is their "deadband" of control at zero rpm. (Deadband is that small range of rpm between minimum-controlled forward speed and minimum-controlled reverse speed. It is also a measure of the "step" change in speed unavoidable during reversal.) With relays doing the reversing, control in vicinity of zero rpm is not possible: relays must both be deenergized to stop motor.

Not all conventional reversing controls require relays. There are some bidirectional controllers that use thyratron-type controlled rectifiers (see Editor's Note); they will work without reversing relays. The circuitry is similar in many ways to that for SCR's—thyratrons are controlled rectifiers too. However, the mercury vapor or xenon gas inside the thyratron has a long de-ionization time that interferes with accurate triggering, and the voltage drop through a thyratron is 10 times greater than for an SCR. Also, precise control at very low speeds requires complicated circuits for thyratrons.

STEPLESS REVERSING

Stepless reversal through zero speed is possible with the SCR's shown in the schematics on the next page because



NEW SCR CONTROL is fully reversible without relays. Triggering circuit (shown as simple box) is heart of drive, and controls each SCR independently. Nonregulated version operates in open loop—motor speed varies with knob position but depends on load. Regulated version has compensating circuit that senses armature potential (a function of load and speed) and holds given speed despite load variations.

reverse potential can be gradually applied to the motor, even before forward potential is removed. This overlapping removes the deadband usually found at zero speed. Power loss at standstill is almost negligible even though two SCR's are firing (on alternate half-cycles). It has been found that the motor does not overheat even though its fan is stopped.

To show how back-to-back SCR's eliminate deadband: a ½-hp dc motor is running at 1000 rpm, and is to be slowed down and reversed until it turns at minus 100 rpm. At the 1000-rpm forward speed, the forward SCR is already energized (phase-controlled with magnetic trigger) and is conducting power. To lower the speed, the SCR is phase-controlled to conduct less and less power until motor turns at 50 rpm (still forward). Then the reverse SCR is slightly energized (while the forward SCR still conducts some power) and motor slows down more. When reverse SCR and forward SCR are each conducting equally (but with very small power) the forward motor torque balances the reversal torque—and the motor stops. Further variation increases reverse power and reduces forward power until the desired minus 100 rpm is reached. At no point is there an abrupt change in speed or power; and all of the operation is controlled by turning a single knob that can be located remote from the control.

If a small deadband is allowable, then firing relationship of the SCR's can be adjusted to eliminate overlapping, reducing standstill losses to zero.

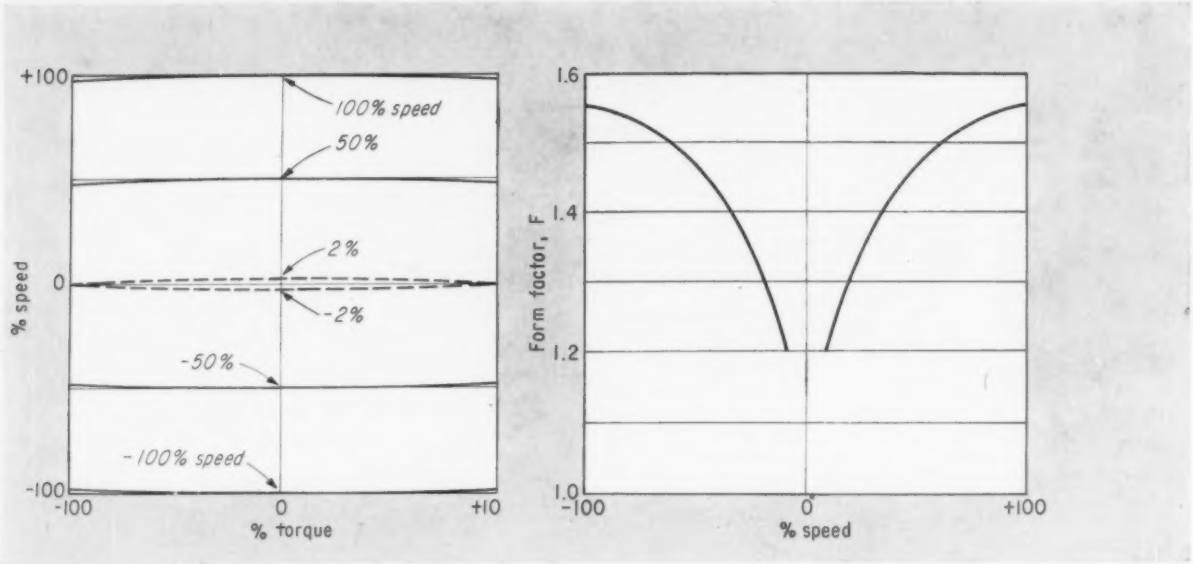
For instantaneous full reversal of motor polarity, the control knob can be moved quickly through entire range. An additional feature is transient dynamic braking occurring during slow-down of the motor; the faster the control knob is moved, the greater is the resulting dynamic braking. But be sure that impedance of motor is in the correct range to limit inrush currents to values less than maximum surge rating of SCR's.

There are no moving parts, except the motor armature, in the SCR reversing drive. All elements are either solid-state or magnetic; are therefore quiet and arcless; and are easily protected by encapsulation from adverse environments. Life is long because there are no wearing parts in the control. One limitation is maximum temperature; junction of an SCR must not exceed 300 F, or failure will eventually occur. However, conventional controllers (most of which use semiconductor diodes anyway) have similar temperature limitations.

Measuring performance

Performance of the new reversing drive is best measured in terms of "speed regulation" and "form factor." Speed regulation is the percent loss in speed (based on full speed) occurring during application of full torque for a given

Performance of SCR Reversing Drive



SPEED REGULATION AND FORM FACTORS here are for actual ¼-hp dc motor driven through regulated version of SCR reversing control. Left chart shows typical speed regulation if control is adjusted for general duty. Right chart (form factor) is plot of ratio of incoming rms ac to useful dc component reaching armature. Ideal value is 1.0, practical value is about 1.5. Interesting is the fact that form factor actually improves as speed is reduced.

control-knob setting. The left-hand chart above shows that there is 2% regulation in a ¼-hp SCR drive adjusted for general-purpose duty. *IR* adjustment built into control allows "flat" regulation (negligible drop) at any given speed.

Form factor is the ratio of (root-mean-square ac flowing into control) to (dc component actually made available to the motor armature). Ideal value is 1.0, but practical value for most conventional variable-speed dc motors is 2.2 (half-wave), increasing slightly (becoming poorer) as motor is slowed down. The new SCR reversing drive has a form factor of 1.55 at full speed, but has the unique characteristic of decreasing radically (down to 1.2) at lower speeds. This is an advantage if duty demands much running at low speed.

The control discussed here is half-wave—dc current flows during the half cycle only. Coming soon is a full-wave SCR control that will control higher power and achieve better form factor (about 1.2).

EDITOR'S NOTE: These recent articles cover reversing of variable- and constant-speed motors:

What They're Offering in Electrical Controls, Sep 26 '60, p 40—Machine-tool Exposition report introduces the dc-motor reverser covered in this issue.

Reversal of Electric Motors, Dec 5 '60, p 84—Describes 12 ways to reverse ac and dc motors.

Many unidirectional speed controls for dc motors will work in both directions if motor-terminal reversing relays are used—see these previous acticles:

New Speed Control for Dc Motors, Aug 15 '60, p 41 (also by author Berman)—Detailed discussion of SCR control. (It is similar to new reversing drive in this issue.)

New Dc Motors, Mar 31 '58, p 108—Describes design of thyratron-controlled watercooled dc motor, which is controlled through both field and armature to give wide speed range.

New Variable-speed Motor Drive, Mar 28 '60, p 80—Evaluates new reactor-capacitor drive for dc motors and compares it with variable autotransformer, simple rheostat, and thyratron drives.

—Franklin D Yeaple

your index is ready

A 20-page printed index of all editorial content in the issues of the last six months of 1960 is now ready. Copies may be obtained by writing "Index Vol 31-2" on the Reader Service Card bound in this issue.

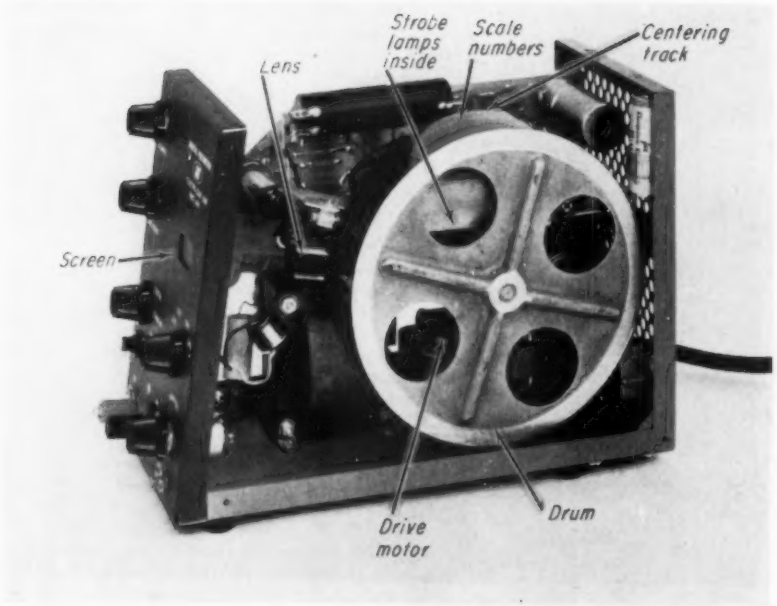
THIS INDEX INCLUDES

- *a subject-classified breakdown of all editorial content*
- *an alphabetical index of authors*
- *an index of company names mentioned in connection with important news or developments.*

The index is issued twice each year, in January and July, and single copies will be sent free on request as long as the supply lasts. A limited supply of the index for the first six months of 1960 (Vol 31-1) is still available.

Voltmeter Projects Readings Movie-style

Strobe lights flash 25 readings a second on screen—observer's eye takes out the flicker.



PS . . . Digital voltmeter has scales for 2.50, 25.0 and 250 v dc; 0.25- and 2500-v dc scales are optional. Alternate method of presentation makes it possible to take readings of fluctuating voltages: Scale appears to slide smoothly across window—like a meter which has a rotating-drum scale and stationary pointer. Controllable damping smooths out rapid voltage fluctuations. Instrument, which has accuracy of 0.5% full scale, is made by Electro-Logic Corp, Venice, Calif.

PROJECTION SCREEN on front flashes 25 successive readings a second. But persistence of vision blends the readings into a continuous image just as it does with a movie.

Projector behind the ground-glass screen consists of strobe lamps and a drum rotating at 1500 rpm. On its outer surface is a transparent filmstrip with numbers 0 to 250, which stand for test voltages. Each revolution of the drum passes this sequence of numbers in front of the strobe lamps. At the right number they fire, projecting the reading on the screen through a lens system. It's done this way:

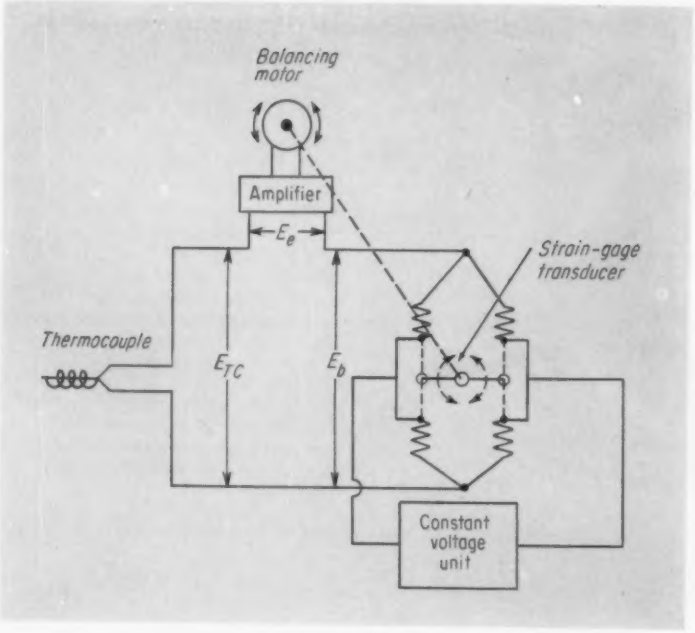
Controlling the strobe lights is an electronic circuit that continually compares test voltage against output of a potentiometer. Potentiometer and drum are connected to each other and to a drive motor so they rotate at same speed. As the potentiometer rotates, a finger picks up the comparison voltage which varies linearly from zero at the beginning of a turn to a maximum at the end of a turn. At the instant the test voltage and this varying voltage are equal, the strobe lights fire, projecting a number corresponding to potentiometer reading. Another electronic circuit adjusts firing time so that the projected number is always centered on screen.

Strain-gage Transducer Has Infinite Resolution

Resistance in millivoltmeter's balancing circuit is varied by stretching current-carrying wires. This gives continuous range of readings, not broken into steps.

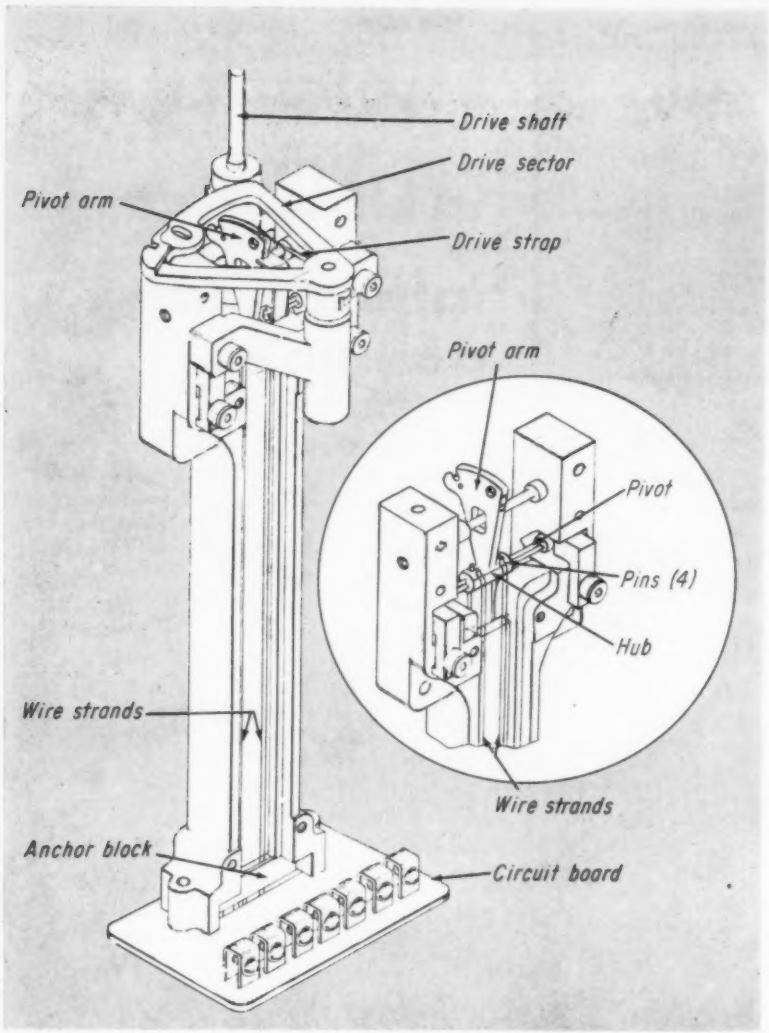
BRUSHED ALUMINUM FRAME and neutral gray mat surround the charts, pointers and scales to allow easy reading regardless of light levels and surrounding colors. They also provide an easily changeable front panel to match the interchangeable modules that make up the various strip-chart, circular-chart and circular-scale indicating models. The aluminum frame isolates each instrument from its neighbors in large, multiple installations—yet it can also lend a unifying identity to such control displays.

Pointers are red for maximum visibility and have been made as large and as free of other elements in mounting as operating considerations such as weight would allow.



BASIC DIAGRAM shows how the strain-gage transducer (Stranducer) balances the millivolt input from a sensing device such as a thermocouple, or any other d-c millivolt source, against the voltage produced by a wheatstone bridge and constant-voltage source. A rise in the thermocouple temperature increases input voltage E_{TC}. When this occurs, the thermocouple voltage E_{TC} no longer equals the bridge voltage E_b, and an error signal or potential E_e is produced. The amplified error signal rotates the balancing motor. This rotation alters the position of the strain-gage transducer which, in turn, changes the resistance of the bridge network until the circuit is rebalanced. When $E_{TC} = E_b$, and $E_e = O$, the motor stops.

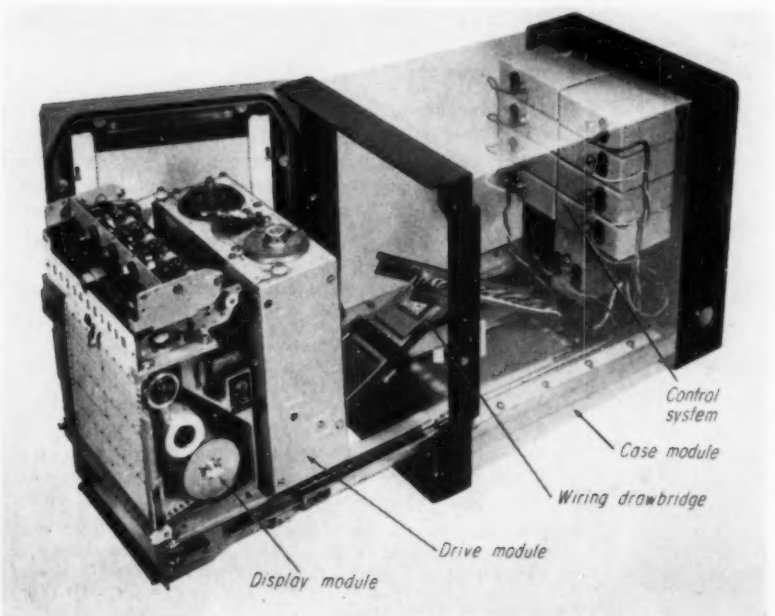
PS . . . Potentiometer, a self-balancing precision millivolt meter, can measure, record, or control such variables as pH, spectrographic quantities, radiation, speed, vacuum, mechanical strain, temperature, pressure, flow. The 3 basic models available are strip-chart recorder, circular-chart recorder, and circular-scale indicator. Instrument features include: continuous-balance potentiometer system with infinite resolution; modular construction; universal cold-junction compensation; greater than 100,000-ohm input impedance, with up to 50,000-ohm allowable source impedance; 31-day recording with strip charts; 24-hour recording with circular charts; calibrated accuracy of ± 0.25%. Changing one printed circuit card changes instrument range. Industrial design by Henry Dreyfuss, NYC. ElectroniK 17 is produced by Minneapolis-Honeywell Regulator Co, Brown Instrument Div.



ELECTROMECHANICAL STRAIN-GAGE TRANSDUCER replaces the conventional slidewire, this eliminates contact problems and extraneous electrical effects, and provides infinite, not stepwise, resolution. Four looped-wire strands form the variable-resistance legs (Wheatstone bridge) of the measuring circuit. Both ends of each wire are attached to an insulated anchor block located at the base of the frame. This block acts as a heat sink. Upper section of the frame houses a horizontal torsion pivot, center of which is a pivot hub over which the four wires are looped. A pivot arm attached to the hub is mechanically linked to the circuit-balancing motor by two stages of strap and sector reductions. The straps and sectors are kept under tension by torsion force of the pivot plus a spring. Any movement of the balancing motor produces a torsional movement of the pivot.

A change in input voltage drives motor in one direction or the other. This increases tension on one pair of the looped wires, decreases tension on the other pair, and alters the resistance of the wires. Resistance continues to change until the electrical bridge is rebalanced. When the balanced position is reached, motor movement stops.

The pen carriage or indicator pointer is also linked to the balancing motor, and the same movement that balances the bridge, positions the pen or pointer. These units are in phase at all times.



INSTRUMENT PACKAGING is based on three building-block modules which can be assembled in various combinations to perform the desired function. Display module can be removed or installed with a screwdriver for service or conversion of strip-chart recorder to circular-chart recorder or circular-scale indicator. Drive module is common to all instruments in group. This module houses Stranducer, range card, actuation board, amplifier and zener-supply unit. Removable side-panels provide ready access. Case module is common, fits standard 19-in. relay rack. With carrying handle attached to case, unit becomes portable. Case houses drive and display modules, drawer-type chassis, wiring drawbridge, control units and their power supply plus a terminal board on the rear.

nine lectures on MECHANISMS

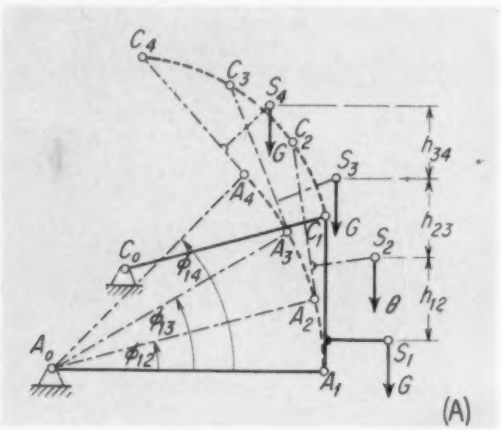
1...SPRING MECHANISMS–force analysis
2...SPRING MECHANISMS–point balancing
3...SPRING MECHANISMS–continuous balancing
4...POWER CYLINDER MECHANISMS–full stroke
5...POWER CYLINDER MECHANISMS–intermediate positions
6...FEEDER MECHANISMS–types
7...FEEDER MECHANISMS–applications
8...FEEDER MECHANISMS–angular motions
9...FEEDER MECHANISMS–curvilinear motions

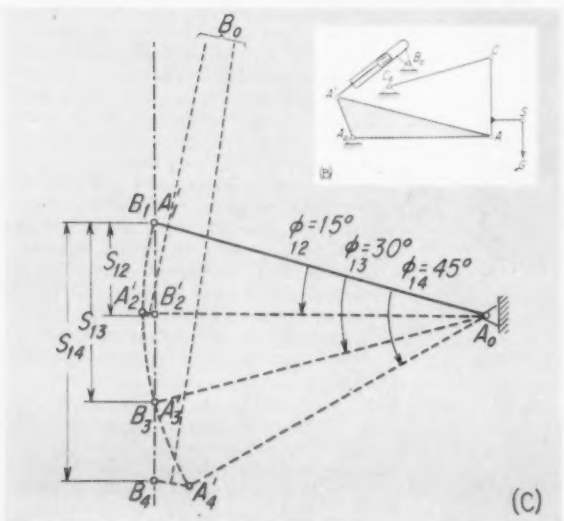
5...POWER CYLINDERS—

intermediate positions

KURT HAIN, *Institute for Fundamental Research, Brunswick, Germany*
Translated by F R Erskine Crossley, Yale University

Graphical methods solve the coordination of linear motion of piston with angular motion of mechanism.





In power-cylinder mechanisms it is sometimes desirable to divide the output angle into several equal portions which are predetermined and controlled by partial stroke lengths of the cylinder piston. The problem here is to coordinate the linear motion of the piston with the angular motion of the mechanism. Consider, for example, the mechanism in Fig 1(A) which is designed to lift a weight G of 200 lb through an angle $\phi_{14} = 45$. Dividing this angle into 3 equal parts gives $\phi_{12} = 15$, $\phi_{13} = 30$, $\phi_{14} = 45$. Assume the corresponding lifts to be $h_{12} = 11$ in., $h_{23} = 10\frac{1}{4}$ in., and $h_{34} = 9\frac{1}{4}$ in. Amounts of work required are:

$$A_{12} = Gh_{12} = 2200 \text{ lb-in.}$$
$$A_{23} = Gh_{23} = 2050 \text{ lb-in.}$$
$$A_{34} = Gh_{34} = 1850 \text{ lb-in.}$$

If the piston stroke is assumed to be $s = 10$ in., partial piston displacements for intermediate positions are:

$$s_{12} = s \cdot \frac{A_{12}}{A_{12} + A_{23} + A_{34}} = 3.44 \text{ in.}$$

$$s_{23} = s \cdot \frac{A_{23}}{A_{12} + A_{23} + A_{34}} = 3.34 \text{ in.}$$

$$s_{34} = s \cdot \frac{A_{34}}{A_{12} + A_{23} + A_{34}} = 3.03 \text{ in.}$$

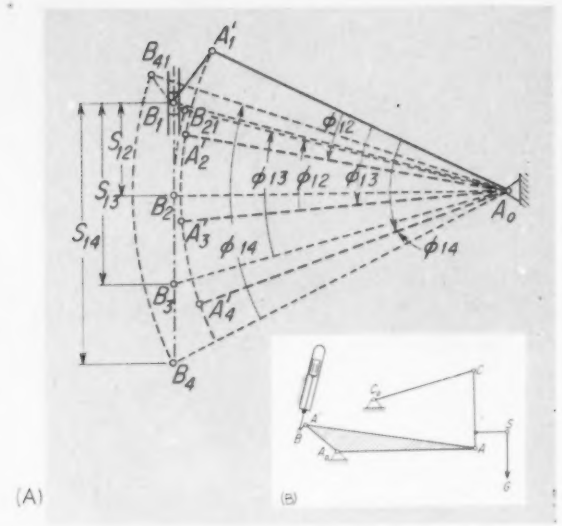
Pivoted cylinders

One choice of mechanism for lifting this weight G with center of gravity S is shown in 1(B) with a side-pivoted cylinder. While this type of arrangement permits a compact design, the offset pivot creates a side thrust which requires cylinder guides capable of withstanding the turning moment. A compound linkage, however, offers more efficient transmission of the piston force.

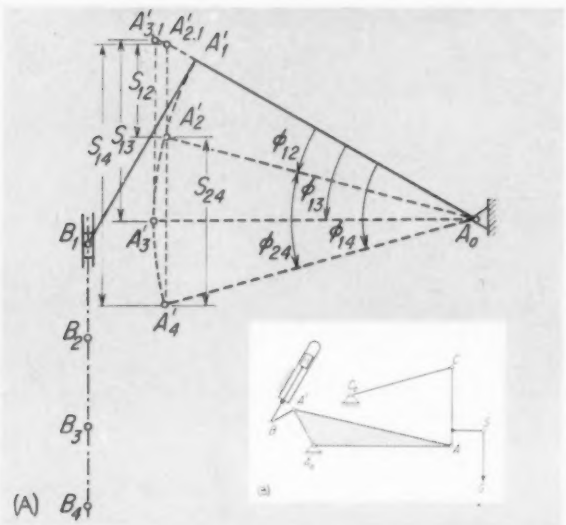
Fig 1(C) shows how a compound linkage can be laid

1. LAYOUT OF A LIFTING LINKAGE (A) for predetermined positions. (B) Pivoted power-driven cylinder can be applied to lifting linkage to give a compact design as shown here, but at expense of high side thrust. (C) This layout coordinates intermediate positions of piston with corresponding positions of output swing determined in (A).

From the text for the Refresher Course in Mechanism 1959/1960, arranged and sponsored by the Chamber of Commerce & Industry of the City of Brunswick, Germany, in cooperation with the Division of The Science of Mechanism of the Society of German Engineers (VDI). Course director: Kurt Hain.



2. FOR FIXED CYLINDERS (A) coordination of intermediate piston and output-arc positions is determined by the point-position-reduction method. This layout gives one solution, and its application is shown in (B).



3. ANOTHER SOLUTION (A) by the point-position-reduction method may be desirable for some applications. Resulting linkage is shown in (B).

out for a pivoted-cylinder arrangement with 3 partial strokes, s_{12}, s_{13}, and s_{14}, and the corresponding angular displacements $\phi_{12} = 15$, $\phi_{13} = 30$ and $\phi_{14} = 45$ already determined. The distance s_{13} is chosen as the base of an isosceles triangle, in which the angle of swing ϕ_{13} is the apex angle. This establishes point A_o and also the length of arm $A_oA'_1 = A_oA'_3$, then from angles ϕ_{12} and ϕ_{14} the points A'_2 and A'_4 can be found. Now if the perpendicular bisectors of A'_2B_2 and A'_4B_4 are drawn, their point of intersection will locate the point B_o, which is the pivot point for mounting the power cylinder. After this, the given dimensions of the four-bar linkage such as determined in Fig 1(A) can be laid out. Dimensions of the particular power cylinder chosen will determine the distance AA′, which can be usually adjusted to suit at assembly.

Fixed cylinders

For fixed cylinders there are two fundamentally different solutions as shown in Fig 2 and 3. In Fig 2(A) the three given partial strokes s_{12}, s_{13}, and s_{14} are shown together with the corresponding angular displacements $\phi_{12} = 15$, $\phi_{13} = 30$, and $\phi_{14} = 45$. The distance s_{13} is used as the base line of the isosceles triangle $B_1A_oB_3$, with ϕ_{13} as the apex angle. With A_o as a turning point, line A_oB_2 is swung through an angle ϕ_{12}, and the line A_oB_4 through an angle ϕ_{14}, in the opposite sense of direction to that in which the link A_oA' turns from its station 1. These rotations move point B_2 around to $B_{2.1}$ and B_4 to $B_{4.1}$. If point B_3 were similarly turned back through the angle ϕ_{13}, B_3 would be found to coincide with point B_1. This coincidence is a result of the construction with the isosceles triangle, and is an example of the so-called point-position-reduction method. The center of the circle, which can be drawn through the three points B_1,$B_{2.1}$, and $B_{4.1}$ is the point A', which determines the crank length $A_oA'_1$. A circular arc is next described through A'_1 with center at A_o, and it is cut with arcs with centers at B_2, B_3, and B_4 and radii equal to the length $B_1A'_1$. This establishes points A'_2, A'_3, and A'_4, which form the equal angles, $A'_1A_oA'_2 = A'_2A_oA'_3 = A'_3A_oA'_4$, and completes the desired coordination of the partial piston strokes with the crank angles ϕ.

Fig 2(B) shows how the four-bar linkage thus developed can be coupled to the lifting linkage A_oACC_o and the fixed cylinder. Once again, the whole four-bar linkage can be swiveled around point A_o to provide any adjustments that may be required by the particular power cylinder that is chosen. When the relative positions are settled, the distance AA′ will be established.

Fig 3(A) shows the second method for developing the design of a four-bar linkage actuated by a piston in a fixed cylinder. Again, the isosceles triangle is constructed with partial stroke $s_{24} = s_{14} - s_{12} = 8 - 3 = 5$ in., used as the base in this example. This corresponds to the crank angle $\phi_{24} = 30°$. With center at this apex point A_o, an arc is drawn to pass through A'_2 and A'_4, and with the angles ϕ_{12} and ϕ_{13}, points A'_1 and A'_3 are located. In the direction of the baseline $A'_2A'_4$ and parallel to it, we now move the point A'_2 through a distance s_{12} to $A'_{2.1}$, and the point A'_3 through a distance s_{13} to $A'_{3.1}$; these displacements must be in opposite sense of direction to which piston wrist pin moves when passing through corresponding stations.

Similarly, point A'_4 can be shifted through the distance s_{14}, and it would coincide with point $A'_{2.1}$; this is another example of the so-called point-position-reduction method. The circle which passes through the three points A'_1, $A'_{2.1}$ and $A'_{3.1}$ is drawn, and its center is the point B_1 of the linkage. The line of action of the piston is the line through B_1 parallel to the base line $A'_2A'_4$ of the isosceles triangle. The succeeding three points B_2, B_3 and B_4 are located by striking off arc from the centers A'_2, A'_3 and A'_4, all having **a radius equal to $B_1A'_1$.** This means that:

$$B_1B_2 = s_{12},\ B_2B_3 = s_{23},\ \text{and}\ B_3B_4 = s_{34}.$$

In Fig 3(B) the four-bar linkage thus developed is shown coupled to linkage A_oACC_o, and again linkage can be adjusted relative to point A_o to establish point A'.

REPRINTS: The nine articles in this series will be available as a combined reprint for $1.00 after the series is complete. Address: Reader Service Department, Product Engineering, 330 W. 42nd St, New York 36.

7 reliability tests for

SYNTHETIC-RUBBER COATED FABRICS

A previous article (Oct. 26 '59, p 68) discussed the factors governing the selection of coated fabrics for industrial diaphragms. When the selection has been narrowed down to the group of fabrics likely to serve a specific purpose, the series of tests in this follow-up article will find the most suitable among the selected fabrics, and ensure that the fabric will perform satisfactorily under the service conditions.

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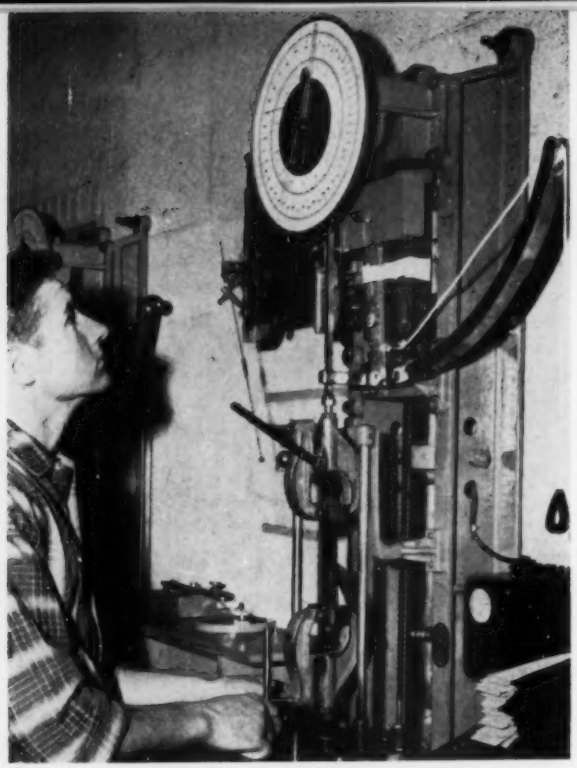
New York City

The seven most common tests for coated fabrics are illustrated in this series of pictures. Wherever a specific standard test method is shown, reference is made to it in the photo caption. The accompanying table lists these standard tests, along with a number of others that can be specified.

If all facilities for conducting these tests are not available, you can normally rely on the fabric supplier to perform these tests for you. Tests 1 to 6 are standard procedure in product development and in quality control at the Vulcan Div of Reeves Brothers Inc. Tests 7 and 8 are part of the test procedure at Bendix-Westinghouse Automotive Air Brake Co. Because of the critical application of

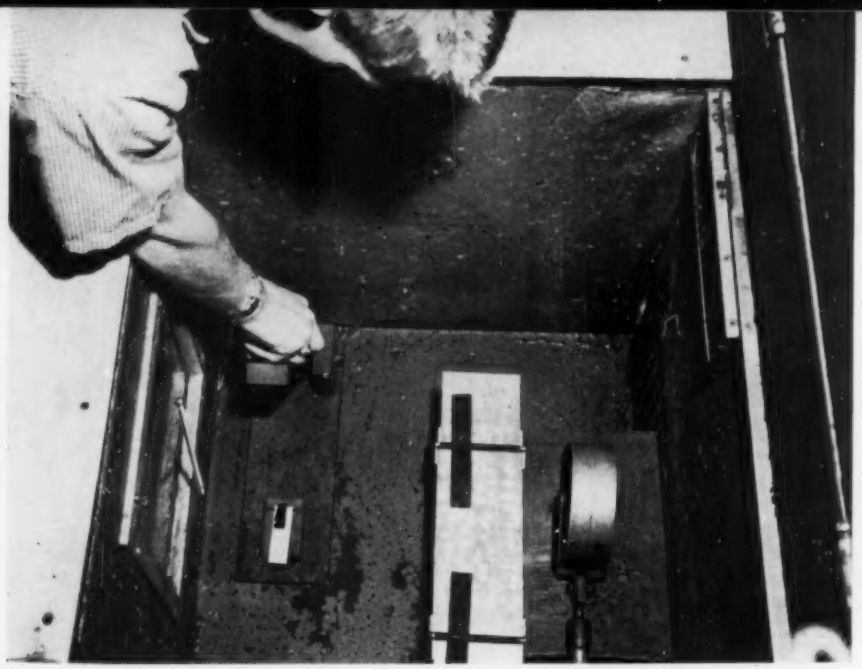
text continued, page 40



1 . . ADHESION TEST determines peel-strength adhesion between two plies of fabric, or between surface coating and the fabric. It also serves as a quality-control test. A 2-in.-wide sample of the material is inserted in a Scott Tester. The jaws separate at a speed of 12 in. per minute. The pawls, which normally keep the weighted arm from dropping back, are raised so that the fluctuation in adhesion can be read from the dial. Peel-strength value is expressed in pounds per inch of width. When testing adhesion between coating and the fabric, two samples are cemented together to prevent stretching the coating. Reference tests: Fed Spec CCC-T-191b, Method 5950; and Fed Std No. 601, Method 8211.

TEST METHODS APPLICABLE TO SYNTHETIC RUBBER-COATED FABRICS
(tests listed in heavy type are those covered by pictures)

TEST CATEGORY AND DESIGNATION	TEST TITLE
ADHESION:	
Fed Spec CCC-T-191b,	
Method 5950	**Adhesion of Plied (Double-texture) Fabric**
5960	Adhesion of Cemented Seams
5962	Adhesion of Strapped Seam
5964	Adhesion of Wet Seams
5970	Adhesion of Coating—Solvent Method
5972	Adhesion of Coating—Water-resistance Method
Fed Std No. 601,	
Method 6411	Adhesion, Change in Hose, Immersion
8031	Adhesion, Rubber to Metal
8211	**Adhesion, Coating to fabric**
8311	Adhesion, Seams (seam strength)
ASTM,	
Method D751–59T	Testing Coated Fabrics (adhesion of coating to fabric)
D429–58	Adhesion of Vulcanized Rubber to Metal
D413–39	Adhesion of Vulcanized Rubber (friction test)
LOW TEMPERATURE:	
Fed Spec CCC-T-191b,	
Method 5874	**Temperature, Low, Effect on Coated Cloth**
Fed Std No. 601,	
Method 5211	Low Temperature, Flexibility, Bending Beam
5311	Low Temperature, Brittleness, Motor-driven Apparatus
5321	Low Temperature, Brittleness, Solenoid-driven Apparatus
5611	Low Temperature, Stiffness, Torsional
Mil Spec C-20696	Cloth, Coated Nylon



2 . . COLD-BOX TEST determines the temperature at which coated fabrics crack—important to know for fabrics that may have to perform outdoors in cold climates. Shown here in one cold box are three different methods: **At left:** a bent loop and hammer test. The weight being held up by the operator is allowed to fall on the bent-loop sample. Cracking of the fabric indicates failure. **At center:** a test jig specified in MIL-C-20696; Cloth, Coated Nylon. Two 1-in.-wide samples, are shown threaded under a ⅛-in.-dia bar which forms the hinge between the center plate and the shorter plate on each end. To perfom the test, end plates are lifted and then allowed to drop on the center plate, flexing the sample around the bar. Sample is then examined for cracks in the coating. **At right:** a 10-lb roller used in Fed Spec CCC-T-191b, Method 5874. An 8-by-8-in. sample is exposed flat and, at the proper test time and temperature, is folded in one direction and the roller is run over the fold. Sample is then folded the other way and roller pressure again applied. Sample may be examined for cracks, or tested hydrostatically.

All these tests are performed at progressively falling temperatures until cracking occurs. Sufficient time must be allowed at each temperature plateau to allow samples and equipment to reach equilibrium. A thermometer is read through the window at left.

3 . . SWELLING TEST determines the percentage volume change when samples are immersed in various liquids. Besides indicating which liquids can be expected to have a damaging effect, it serves as a quality control. Oblong-shape samples that will slide readily into a glass storage tube are prepared. Immersion in a graduated clyinder (on scale) gives volume of the sample. Alcohol is widely used for volume measuring: it permits a sample to sink, does not cause swelling, is water-clear. Sample is then dried and transferred to a glass storage tube (in rack at right) containing the swelling medium to be studied. At stated intervals, after storage at the desired temperature in a closed tube, the sample is removed and dried rapidly and carefully. Volume is again measured, and any increase is recorded as a percentage of the original volume.

table continued, next page

LOW TEMPERATURE: (continued)		
ASTM,		
	Method D736–54T	Low-temperature Brittleness of Rubber & Rubberlike Materials
	D746–57T	Brittleness Temperature of Plastics & Elastomers by Impact
	D1053–58T	Measuring Low-temperature Stiffening of Rubber and Rubberlike Materials by Means of a Torsional Wire Apparatus
	D797–58	Young's Modulus in Flexure of Natural and Synthetic Elastomers at Normal and Subnormal Temperatures
SWELLING:		
Fed Std No. 601		
	Method 6211	Change in Volume, Liquid Immersion
	6231	Change in Thickness, Immediately After Liquid Immersion
	6241	Change in Thickness, Liquid Immersion, After Recovery
	6251	Change in Weight, Liquid Immersion
	6311	Change in Laminated Materials, Liquid Immersion
ASTM,		
	Method D471–59T	Change in Properties of Elastomeric Vulcanizates Resulting From Liquid Immersion
	D378-51T	Testing Flat Rubber Belting—Oil-Immersion Test

coated diaphragms in air brake components, Bendix-Westinghouse tests on coated fabrics are probably more severe and thorough than in any other industry.

EDITOR'S NOTE: Recent articles on materials and processes that depend upon fibrous raw materials, either natural or synthetic, include:

Which Process for Fiberglass-reinforced Plastic Molded Parts, Jan 11 '60, p 47—Special report selects 7 key processes out of the 15 available; explains their strong and weak points; shows how one or the other becomes logical choice in most commercial-volume applications.

Coatings and Fabrics for Today's Diaphragms, Oct 26 '59, p 68—Selection charts guide you to the right base fabric and elastomer coating.

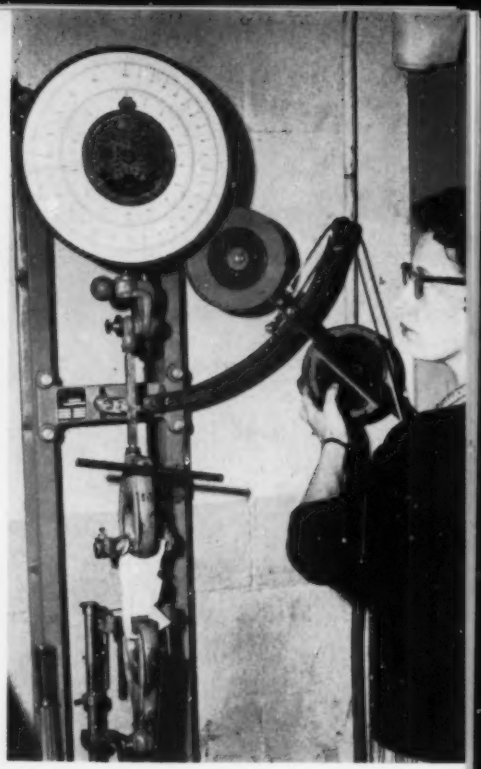
Applications and Treatments for Felts, Mid-Oct '57, p C-8—Discusses five treatments that give felts special properties and summarizes the engineering situations where they find use.

Fiber-base Structural Materials, Feb '57, p 164.—Ready-reference chart lists properties of three vulcanized-fiber grades, compares them to those of six other load-bearing materials based on natural fibrous materials.

Ford Park

TEST METHODS APPLICABLE TO SYNTHETIC RUBBER-COATED FABRICS
(tests listed in heavy type are those covered by pictures)

TEST CATEGORY AND DESIGNATION		TEST TITLE
TENSILE:		
Fed Spec CC-T-191b		
	Method 5100	**Strength and Elongation of Woven Cloth, Grab Method**
	5102	Strength and Elongation, Breaking, Woven Cloth (cut strip)
	5104	Strength and Elongation, Breaking, Woven Cloth (ravel strip)
	5122	Strength of Cloth, Diaphragm-bursting Method
ASTM,		
	Method D334–40	Cotton Goods for Rubber and Pyroxylin Coating
	D751–59T	Testing of Coated Fabrics
WICKING:		No standard tests exist similar to this special test
FLAMMABILITY:		
Fed Spec CCC-T-191b,		
	Method 5900	Flame Resistance of Cloth, Horizontal
	5902	**Flame Resistance of Cloth, Vertical**
	5904	Flame Resistance of Cloth, Vertical (field)
	5906	Burning Rate of Cloth, Horizontal
	5908	Burning Rate of Cloth, 45° Angle
	5910	Burning Rate of Cloth, 30° Angle

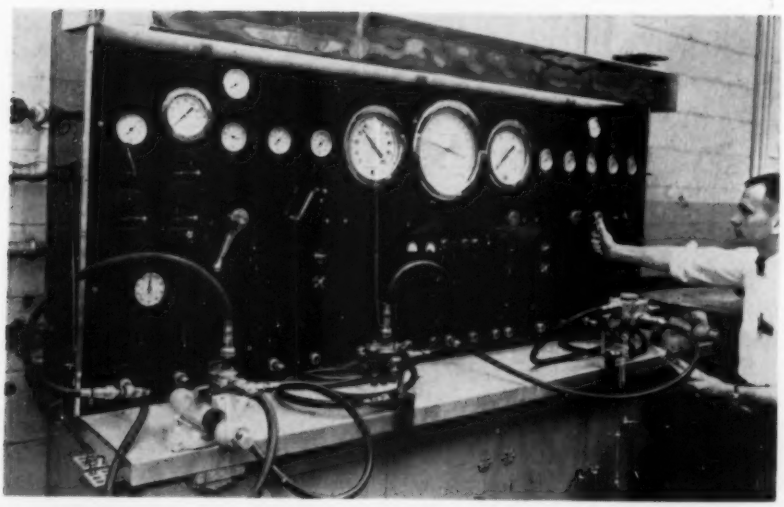


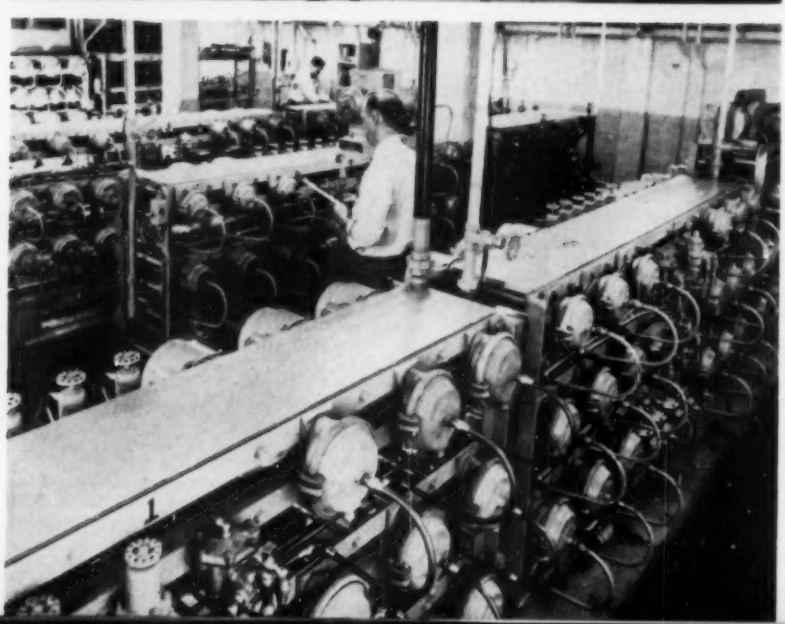
4 . . TENSILE TEST, known also as the grab test, determines breaking strength of a piece of fabric. Applicable to both coated and uncoated fabrics, it determines one of the most important mechanical properties of cloth. Five samples, each 4 in. x 6 in., are cut parallel to the warp and five parallel to the filler, then inserted in the Scott Tester so that exactly the same group of yarns is being held in both the upper and lower jaws. These jaws, three inches apart at start of test, then separate at speed of 12 in. per minute. The breaking strength is read from dial. The pawls on quadrant hold the weighted arm at the breaking point for record purposes. Reference test: Fed Spec CCC-T-191b, Method 5100.

5 . . WICKING TEST is a special—it determines the pressure a coated fabric can withstand without leaking gas radially through the fabric center from an open edge or through a pinhole in the coating. Gas entering the fabric this way bleeds through the flanges to the outside edge. The flange-clamping pressure must be just sufficient to prevent loss of gas between the sample and the flanges, but not so high as to impede flow of gas through the yarns. Several variations in the sample are used: a center hole with exposed edges, no hole other than a pinhole made in the coating on the pressure side, or a lapped seam to study methods of seaming. Sample shown here protrudes about an inch from the holder. Central portion of the holder has a generous cavity above and below the sample, and the flange bolts are carefully tightened with a torque wrench. Test jig, connected to a gas supply, is immersed in water. Gas pressure is raised gradually until streams of bubbles are visible at the yarn ends around the periphery. This test was developed by Reeves-Vulcan engineers as a rigorous check on coated fabrics for diaphragms used where pressure loss cannot be tolerated.

SYNTHETIC RUBBER COATED FABRICS

6.. FLAMMABILITY TEST measures flame resistance of a coated fabric. The sample, 2¾ in. x 12 in., is clamped between metal flanges and suspended in a metal cabinet to shield it from drafts. Size of the flame with standard gas fuel is specified, and it is placed under the sample for 12 seconds. Without opening the cabinet, the burner is then pulled away. A stopwatch measures how long the flame persist after burner is removed. Then, the length of afterglow time is recorded. persists after burner is removed and the char length is measured. Reference test: Fed Spec CCC-T-191b, Method 5902.





7.. OPERATIONAL TESTS are a final check and are run—either in the laboratory or the field—on the actual equipment for which the coated fabric was designed. Shown here are two examples, setups designed by Bendix-Westinghouse Automotive Air Brake Co to check brake-diaphragm materials.

At top: a valving setup for a trailer air brake system is tested on a specially designed pressure console. Here, the diaphragms, installed in the actual components, are checked for such operational characteristics as: air flow, leakage, wicking, response to pressure differentials, noise and creep. Panel registers every type of air load and change in load through air gages, timers, counters etc. Typical test lasts 100 hr.

At bottom: life-test room where B-W checks whether a unit and its individual components, such as the diaphragm, retain full operating characteristics for at least 1 million cycles at max pressure. Several hundred items, brake cylinders as well as air valves, are tested simultaneously. Other operational tests are often adapted from tests 1 through 6. For example, a brake diaphragm that posed special wicking problems had a breather hole, ¼ in. from outer edge, connecting top and valve chambers. A special wick-test jig applied 100-psi air pressure to edges of the breather; any seepage through the fabric was detected at the outer edges by means of a soap solution.

For REPRINT of above article, just check 581 on one of the Reader Service cards bound in this issue.

AREA HEAT SOURCES
answer to hot-spot temperatures

These heating elements use flat conductors with maximum surface area and intimate contact for lower temperature differential. Performance characteristics are tabulated here for five basic types and compared with single-wire heating elements.

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THE CASE FOR FLAT CONDUCTORS

In an electrical conductor used for heating, the basic design problem is to generate the heat and dissipate it at a temperature within the limits of surrounding material. Higher temperatures help increase dissipation but surrounding materials (or people) limit maximum temperatures. Dissipation of heat is improved by a conductor with large ratio of surface area to cross-section. This can be accomplished by using a rectangular section or ribbon, or by using several smaller round wires in parallel.

Replacing one wire with several that are smaller but of equal total cross-section increases the surface area proportional to the square root of the number of smaller wires. Thus 36 wires, 0.010 in. dia, will have the same cross-section as a 0.060-in. wire—but with 6 times the surface area. Or a thin ribbon or film, $\frac{1}{8}$ in. wide and 0.005 in. thick (same cross-section) will have nearly 8 times the surface.

Two kinds of jobs can be done by the method of bonding a low-temperature area heater to the surface of a part. Intimate contact plus uniformly distributed heat can bring the part up to temperature at a fast rate; or provide a thermal dam that prevents a part from losing heat to its environment. The fast-rise application calls for relatively high heat generation, 20 to 50 watts per sq in.; steady-state conditions usually need watt densities of 5 or under. In either case, the bonded-surface heating elements can cover large, curved and irregular areas with uniformly distributed heat. This contrasts with a single conductor that operates at high temperature and delivers hot-spot heat.

The conductors of the area heat source may consist of woven wire mesh, sprayed-on metal or compositions, and graphite fibers. Heating elements are bonded to a thin (usually 0.005 in.) insulating film on the part, and are then covered with a protective film or sprayed-on coating.

These heaters add from 0.012 to about 0.050 in. to the thickness of the part. With such close spacing between heating element and part the temperature difference is small and rate of heat transmission is high.

Weight is in the range of 0.1 to 0.2 lb per sq ft, but may be as low as 0.04 for graphite fibers and up to 0.3 for sprayed metal conductors. Each type has its own particular advantages and limitations, as shown in the table, and vary in maximum temperature, resistivity, abrasion resistance, flexibility, uniformity, cost and size range.

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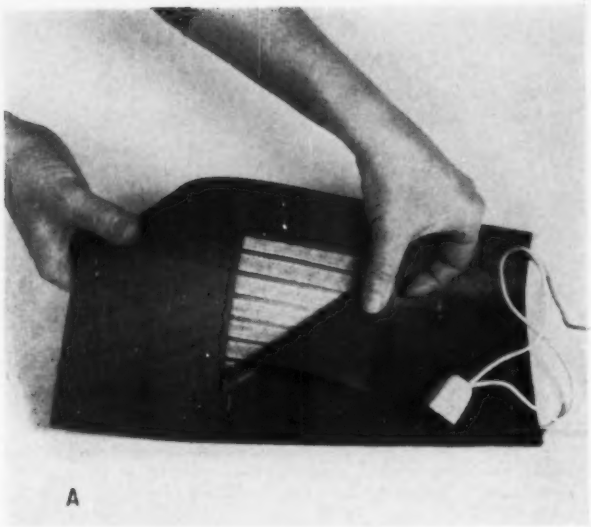
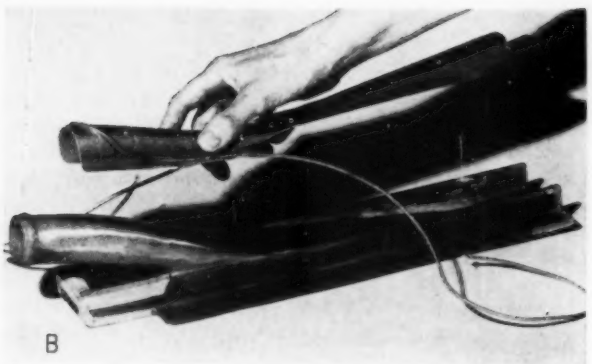


A



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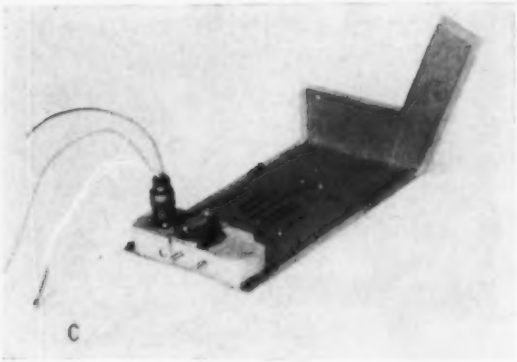


C

1 . . Woven Wire Mesh

A—Detachable flexible heating blanket

B—Rigid contoured separate heater

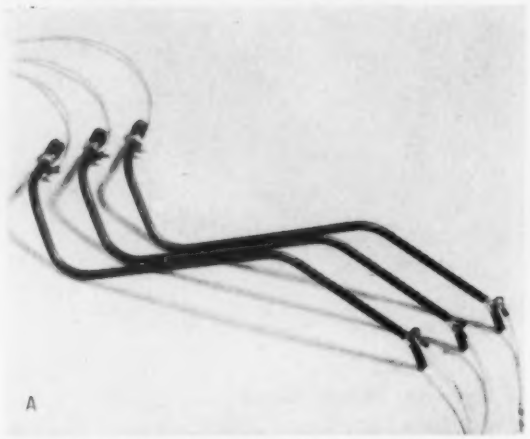
C—Or permanently bonded to part

HEATING ELEMENTS FOR AREA HEAT SOURCES

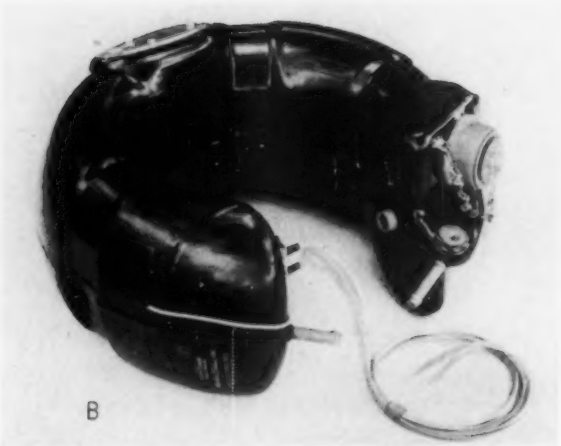
	Woven wire mesh	Sprayed-on Conductors			Graphite fibers	Single wire
		metal	composition	ceramic		
Surface temp, max deg F	600	250	300	600	2300	600
Unit resistance, ohms per square	0.04 to 10	under 5	0.02 to 20	0.02 to 20 (1)	0.05 to 2 (2)	———
Watt density, max watts/sq in.	30	40	15	15–30	40	15–20
Total-thickness range, in.	0.01 to 0.06	0.02 to 0.05	0.011 to 0.015	0.02 to 0.03	0.025	0.01 to 0.06
Weight, lb per sq ft	0.08 to 0.15	0.25 to 0.35	0.07 to 0.12	0.12 to 0.25	0.05 to 0.25	0.08 to 0.15
Cost, finished, $ per sq ft	3 to 25	5 to 100	2 to 50	12 to 50	5 to 50	2 to 50
Size range	1 sq in. to 6 x 12 ft	10 sq in. to 10 sq ft	1 sq in. to 40 sq ft	less than 4 ft sq	(2) up to 40 x 54 in.	1 sq in. to 10 sq ft
Uniformity over heated area	High	High	Good (3)	Fair	High	Poor
Flexibility	High	(4)	Fair	Poor	Good	Good
Sturdiness	High	Good	Good	Fair	Fair	High

Notes: (1) Unit resistance is difficult to control with precision. (2) Only a limited range available at present. (3) Uniformity decreases with operating temperatures above 200 F. (4) Limited only by the base metal.

2 . . Sprayed-on Composition



Keeps hydraulic fluid in pipe from losing heat



Can be bonded to irregular areas and shapes

UNIT RESISTANCE

For a bonded heating element of uniform thickness, resistivity is conveniently specified by "unit resistance" in ohms per square. The "square" may be in any dimensional unit as long as the thickness is fixed, since resistance of a conductor is proportional to length divided by area. If thickness is assumed constant, the resistance is then proportional to length divided by width, and the dimensional units cancel.

Unit resistance ϕ in ohms for a given conducting material is stated for a specific thickness; for any other thickness the resistivity varies inversely with thickness. Heating elements of the type discussed here are in the range of 0.03 to 50 ohms per square for 0.005-in. thickness.

Heat produced by a given configuration is readily calculated from the unit resistance for the selected heating element. First, find resistance R between terminals:

$$R = \frac{\phi}{t} \times \frac{L}{W}$$

where t is thickness, L is length and W is width, all in inches.

To calculate watt density w for a given supply voltage E,

$$w = \frac{E^2}{R\,(L \times W)}$$

Substituting for R in this equation

$$w = \frac{t}{\phi}\,\frac{E^2}{L^2} \text{ or } t = \frac{\phi\, w\, L^2}{E^2}$$

This shows the important relation between length and supply voltage (squared quantities), and the need for materials with a wide range of unit resistance to keep thickness within reason for differing length or voltage requirements.

Woven wire mesh

Closely spaced fine wires in parallel—up to 50 per in.—carry the current. They are held in position by a woven cross-wire which keeps the width constant and serves as electrical tie between the strands. For a given watt density, multiple conductors distribute heat more uniformly than a single larger conductor and operate at lower conductor temperature for a required watt density. Also, multiple conductors with cross-wires offer parallel paths if a wire becomes broken.

The woven-wire tape is bonded to a layer of flexible or rigid insulation, and covered with glass or nylon cloth impregnated with thermosetting or thermoplastic resin. The laminated conductor may be bonded to the part requiring heat, or may be a rigid detachable contoured heater or a flexible blanket.

Sprayed-on conductors

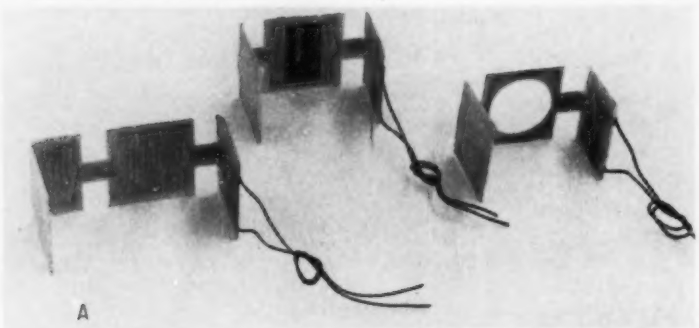
Three types are common—sprayed metal, a mix of conductive particles in a resin binder, or a ceramic-metal mix. For all types a thin insulating base, about 0.005 in. thick, is sprayed directly on the part. The conductor area is outlined with a mask and the conductor applied and cured. Then, a hard abrasion-resistant insulating coating is added to protect and insulate the conductor.

Electrical resistance of the heating element depends on resistivity of the conductor, its thickness, and length and width of the conductor.

Resistivity of sprayed metal is much lower than for composition types consisting of metal particles in a binder. The length of a sprayed metal conductor must be increased and the width reduced by masking to match usual supply voltages. The resistance value remains stable after application, and can be corrected if necessary by sanding or adding metal. Thickness is ordinarily in the range of 0.020 to 0.050 in.; and unit weight is 2 to 3 times that of a composition element. Cost is also higher—but much higher watt densities can be used.

Composition elements are conductive pigments–silver, aluminum or graphite–in a resin binder. These coatings usually are sprayed thin, about 0.005 in., and total thick-

3 . . Single-wire Heaters



A—Wire is sandwiched between layers of resin-impregnated cloth, but could be bonded to part.

B—Watt density is varied, from 20 watts per sq in. at the tip to 7 at the base, by varying wire size and spacing.

ness including insulation may be no more than 0.015 in. This gives a weight of about 0.10 lb per sq ft, obtained with good uniformity. Maximum service temperature is about 350 F, since higher temperatures may cause change in resistivity through further curing of the resin.

Ceramic-bonded material using frits containing particles of silver, stainless or tungsten can be operated at 600 F or higher, but the high curing temperature of 900 to 1000 F poses a problem in insulation and warping of the part. The insulating layer should be thin to transmit heat, but thick enough to reduce electrical leakage at elevated temperatures. The heating element has little flexibility, only fairly uniformity in resistance, and thickness is difficult to control. The metal surface of the part requires careful preparation to produce a good bond, and the coating is easily damaged by impact.

Graphite fibers

This new nonmetal conductor is prepared by a process that "carbonizes" cloths of organic fibers. The resistance element looks and feels like a textile but has the high-temperature properties of graphite, often with an actual increase in strength. As with graphite, the resistivity decreases with temperature by a small amount, while the other forms of heating elements increase in resistance with temperature.

Graphite fibers can be operated at temperatures as high as 2500 F, but for area heat sources the temperature is limited by the insulation. Woven glass, quartz or ceramic fibers may be used when a high operating temperature is needed. High watt density needed to reach a high temperature involves high currents, with accompanying problems in getting the current into the conductor without hot spots at terminals.

High temperatures also introduce problems in fastening the heater to other than horizontal surfaces. Also, insulation thickness must be heavier, which increases cost and weight.

Single wire

This is the familiar type—inexpensive and readily available—but requiring higher wire temperatures for a desired watt density. This introduces problems in heating uniformity and degradation of insulation. Further, one break in the conductor puts it out of order. Unit weight is low, and resistance to abrasion is better than for sprayed-on or graphite elements.

Other design details

Termination of conductors consisting of fine wires or thin films requires a bus construction of low resistance, to reduce heat generation at the terminal. For woven wire, sprayed metal or carbon fiber elements the bus may be copper mesh or strip soldered or clamped to the heater; for sprayed-on composition heaters the bus may be copper mesh or a high-conductivity resin mix. The high-conductivity bus is then brought to a screw terminal or insulated eyelet, or leads are soldered directly to a metal bus. Where one end of the heating element can be grounded, a single terminal post can provide both a grounded and an insulated connection.

Special protective coatings can be supplied on lower-temperature elements (under 350 F) to resist abrasion or water, or provide higher dielectric strength for high supply voltages, or add distinctive color. For higher temperatures a protective coating of glass cloth impregnated with silicone rubber is good for 500 F, with some loss in solvent resistance and dielectric strength.

EDITOR'S NOTE: These earlier articles discuss problems encountered in heating or cooling by conduction, convection or radiation:

Radiant Cooling or Shielding, Nov 14 '60, p 55—Emissivity data and design techniques for balancing heat input and radiation, with brief discussion of radiant-heat transfer theory.

High-temperature Electrical Equipment, Sep 26 '60, p 56—Describes electrical components and materials built to stand high temperatures and kept cool by radiation.

When Air Is the Coolant, Feb 16 '59, p 54—Shows how to estimate whether an assembly will run too hot, and whether the self-cooling methods of radiation or convection can handle the trouble.

—Robert W Carson

these recommendations:

WHEN DESIGNING JOURNAL BEARINGS

Here's a practical approach, based on speed, load and temperature requirements, that goes to the heart of the problem. It leads to the right dimensions, materials, surface finishes and lubricants for the bearings.

BRUCE M DUNHAM, *technical consultant, Sun Oil Company, Philadelphia*

Journal (or plain) bearings are simple, common components—but their successful operation inolves a complex hydrodynamic action. Design theory is still in the refinement-and-debate stage and many designers prefer avoiding mathematical analyses which is complex—and may still fail to produce the best bearing for the job. The alternative is rule-of-thumb methods. But what are the rules to follow?

The recommendations here are simple, but safe. They are based on our own experiences, and on the literature, and cover two groups of variables that affect journal-bearing lubrication:

Mechanical design factors such as speed, load, operating temperature, clearances, metallurgy of bearing and shaft, and surface finish.

Lubricant variables, such as viscosity, method and frequency of application, quantity of oil, and film thickness of oil.

MECHANICAL DESIGN FACTORS

Speed

This is perhaps the most important design factor. It has a direct bearing on the viscosity requirement of lubricant.

Low speeds require heavy (high-viscosity) oils because the slow-moving shaft creates comparatively little of the pumping action needed to pull the lubricant into the loaded area between journal and bearing, and thereby prevent metal-to-metal contact.

High speeds require low-viscosity oils to avoid overheating.

Thus, for any given speed, and all other things being equal, it is the viscosity range that leads you to the best lubrication. Table I on page 48 is a guide to the right oil viscosity for various journal speeds and loading conditions. These recommendations are for journal bearings operating under uniform load conditions at temperatures between 60 F and 140 F. Where extreme or intermittent shock loading exists, extreme-pressure high-film-strength oils of comparable viscosity should be employed.

Load

Heavy loads call for the more viscous oils. However, pressure per square inch can get too high for the mineral oils, causing metal-to-metal contact. In such cases, turn to extreme-pressure (EP) lubricants (compounded or high-film-strength oils). They have greater load-carrying capacity than straight oils of the same viscosities and do not become as heated under heavy loads.

Mild EP lubricants contain both an oiliness agent and extreme-pressure chemicals such as lead, phosphorus, or sulfur. The oiliness agent keeps the coefficient of friction low until temperatures reach its melting point. From this point on, the chemical compounds take over. They react to form sulfide or phosphide films with the metal. These films have higher melting points and lower frictional characteristics than the metal alone.

When is an EP oil necessary? There are no set rules,

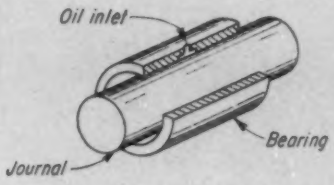
text continued, page 48

SYMBOLS

N = rpm	D = shaft diameter, in.
p = unit pressure, psi	C = radial clearance, in.
L = bearing length, in.	R = radius, in.
z = viscosity, centipoises	

THE MECHANICS OF JOURNAL-BEARING LUBRICATION

■ Shaft member of the bearing unit is usually called the **journal**; its cylindrical casing, the **bearing**. The inside diameter of the bearing exceeds the journal diameter by an amount referred to as the **diametral clearance**.



Components of a journal bearing

It's up to the lubricant to prevent metal-to-metal contact. As the journal rotates, the bearing acts as a pump and draws in the oil through inlet holes. The oil can also be force-fed to assure ample lubrication during starting or slow speeds.

The oil film should be thick enough to maintain fluid friction. Theory has it that the layer of oil molecules immediately in contact with the two metal surfaces is partly absorbed by the metal surfaces. This increases surface slipperiness. The lubricating value of this absorbed firm is very important. The balance of oil molecules adhere to the two metal surfaces, forming a **boundary film.**

If there is insufficient supply of lubricating oil, **thin-film** or **boundary** lubrication takes place. This may occur in machinery when starting or stopping, or when a sudden impact load is applied to a bearing. It may cause either intermittently recurring metal-to-metal contact or actual film breakdown with consequent seizures or welding. Boundary lubrication is usually undesirable and unsafe for machine parts.

Ideal lubrication is with an ample supply of lubricant fed between the metal surfaces in motion. This results in additional intermediate layers of oil molecules, which are held together by cohesion and slide or roll over each other with motion of the surfaces. These molecules act as microscopic ball bearings. Such a thick film is capable of **full-film** lubrication. This type of lubrication is also called **thick-film** lubrication. It maintains the metal surfaces at sufficient distance to overcome the intermolecular forces of the metals so that fluid friction replaces metal friction. In modern machinery a full film formed by a good lubricating oil generally varies in thickness between 0.0002 and 0.0006 in.

Journal action

A journal at rest can have no pumping action and the lubricant is squeezed out leaving the load on metal-to-metal contact, as shown at bottom of page. As the journal starts rotating, it rolls uphill on the bearing surfaces, as in (B). The journal is thus slightly off-center, and the clearance is crescent-shaped, with a wedge-shape end on each side of the load area.

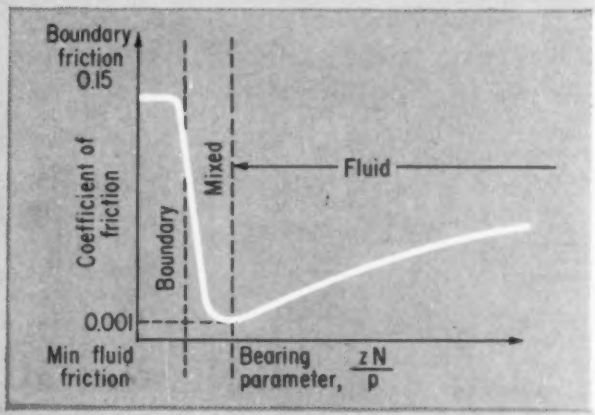
As speed increases, oil is drawn from the clearance space and around the journal, forming a thin oil film or partial lubrication. Pressure buildup in the film lifts the journal and tends to center it in the bearing (C). As speed is further increased, more oil is drawn or pumped into the wedge between journal and bearing, and a full fluid film is built up.

Pressure of the film increases, lifts the journal from the bearing and forces it to the right until all forces are in equilibrium (D). The film pressure causes the oil to flow in all directions from the point of maximum pressure. To form and maintain a full film of oil, a sufficient quantity of oil must be supplied to and maintained in the bearing to compensate for any loss caused by end-leakage.

The proper point to supply the oil is within the low-pressure area, that is, on the unloaded side of the bearing.

Three types of lubrication

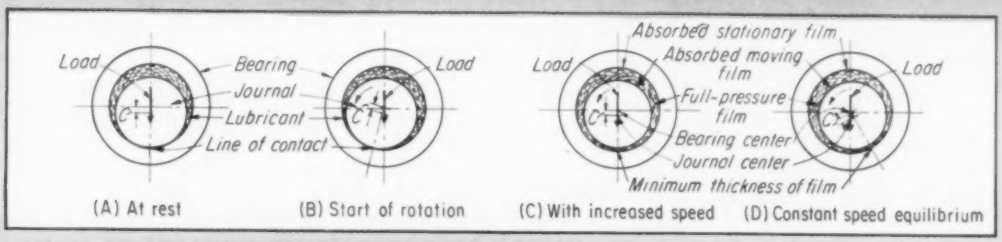
At slow speeds ($zN/p \sim O$), the bearing operates under boundary lubrication (see curve). In this condition, friction depends on the smoothness of the bear ing surfaces, adhesive strength of the oil sticking to the metal surfaces, and to some extent on the viscosity of the oil.



Coefficient of friction versus bearing parameter

As speed increases, or with a more viscous fluid, lubrication in the bearing changes. The film becomes somewhat thicker, and viscosity becomes more effective while the thin film changes to a thick film. This corresponds to the "mixed" region of the curve.

In the last region, when the curve is practically a straight line, fluid friction and thick-film lubrication take place, and are maintained by the oil viscosity.



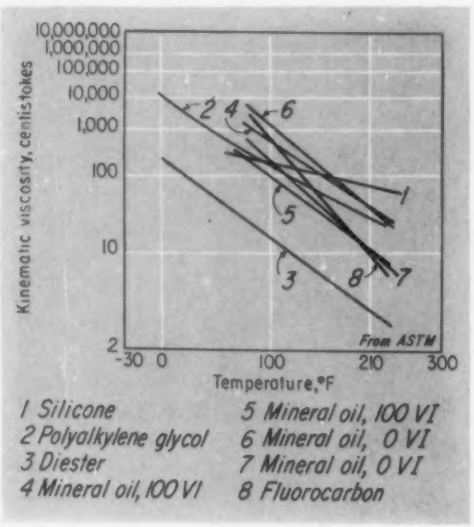
Shift of journal position during changes in speed

I—RECOMMENDED VISCOSITY VS SPEED AND LOAD

Speed, rpm	Light Load (up to 100 psi) Application Method*		Medium Load (100 to 250 psi) Application Method		Heavy Load (above 250 psi) Application Method	
	Continuous	Once-through	Continuous	Once-through	Continuous	Once-through
5000–10,000	40–65	65–85	–	–	–	–
3500–5000	65–85	85–100	–	–	–	–
2000–3500	85–100	100–150	–	–	–	–
1000–2000	100–150	150–300	150–300	300–500	–	–
500–1000	150–300	300–500	300–500	500–800	–	–
300–500	300–500	500–800	500–800	800–1200	–	–
100–300	500–800	800–1200	800–1200	1200–1800	1750–3000	2400–7000
50–100	800–1200	1200–1800	1200–1800	1800–2600	1750–3000	2400–7000
Under 50	1200–1800	1800–2600	1800–2600	2300–3300	2400–7000	2400–7000

*-**Continuous** provides constant flow of oil to the bearings and includes ring and collar oilers, circulating systems, mist or fog lubricators bath or splash systems.

Once-through provides intermittent amounts of oil to the bearings and includes bottle, wick-feed and drop-feed oilers, mechanical force-feed oilers and oilcans.



Viscosity-temperature curves for typical oils

II—RECOMMENDED BEARING DIAMETRAL CLEARANCES

Journal Dia, in.	Medium Fit, in. (below 600 rpm) Tightest Fit	Medium Fit, in. (below 600 rpm) Loosest Fit	Free Fit, in. (above 600 rpm) Tightest Fit	Free Fit, in. (above 600 rpm) Loosest Fit
¼	0.0004	0.0014	0.0006	0.0022
½	0.0006	0.0018	0.0009	0.0029
¾	0.0007	0.0021	0.0012	0.0036
1	0.0009	0.0025	0.0014	0.0040
1¼	0.0010	0.0028	0.0016	0.0044
1½	0.0012	0.0030	0.0018	0.0047
1¾	0.0013	0.0033	0.0020	0.0052
2	0.0014	0.0034	0.0022	0.0054
2¼	0.0015	0.0035	0.0024	0.0058
2½	0.0017	0.0039	0.0026	0.0062
2¾	0.0018	0.0041	0.0028	0.0065
3	0.0019	0.0043	0.0029	0.0067
3½	0.0021	0.0045	0.0032	0.0072
4	0.0023	0.0049	0.0035	0.0077
4½	0.0025	0.0051	0.0038	0.0080
5	0.0026	0.0054	0.0041	0.0085
6	0.0030	0.0060	0.0046	0.0094
7	0.0033	0.0063	0.0051	0.0101
8	0.0036	0.0068	0.0056	0.0108

and selection is a matter of experimentation with specific designs. But here is a list of conditions that may call for them:

- Shock loading
- Intermittent shock loading
- Extreme loading or service loads greater than original design
- Reversing action
- A high safety factor when desired

Operating temperatures

All lubricants change viscosity with changes in temperature. The higher temperatures lower the viscosity, and vice versa. Therefore, the key criterion in selecting a lubricant is its viscosity at operating temperatures—not at room temperature or at the standard 100 F. It is safe to assume that the normal operating range of most industrial plain bearings is between 100 and 150 F. For variations in viscosity with temperature, check the curves above.

III—TYPICAL JOURNAL-BEARING PRACTICE FOR INDUSTRIAL MACHINERY

Machine	Bearing	Method of Oil Application	Maximum Load, psi	Lowest Permissible zN/p	Best Oil Viscocity, SSU @ 100 F	L/D	C/R
Machine tools	Main	Any	300	1	150–500	1.0–4.0	0.001
Punches or shears	Main	Drop oiler	4000	2	500	1.0–2.0	0.001
	Crankpin	Drop oiler	8000	2	500	1.0–2.0	0.001
Electric motors & generators	Rotor	Ring or cup	200	200	150	1.0–2.0	0.0013
Centrifugal pumps	Rotor	Ring or cup	200	200	150	1.0–2.0	0.0013
Reciprocating pumps	Main	Splash	250	30	300–500	1.0–2.2	0.001
	Crankpin	Splash	600	20	300–500	0.9–1.7	0.001
	Wrist pin	Splash	1000	10	300–500	1.5–2.0	0.001
Steam turbines	Main	Circulation	275	100	150	1.0–2.0	0.001
		Ring	100	100	300–500	1.0–2.0	0.001
Gas engines							
2 cycle	Main	Splash or Forced	500–800	25	500–750	0.6–2.0	0.001
4 cycle	Crankpin	Splash or Forced	1000–1500	12	500–750	0.6–1.5	0.001
	Wrist pin	Splash or Forced	1200–1800	10	500–750	1.5–2.0	0.001
	Main	Splash or Forced	700–1200	20	500–750	0.6–2.0	0.001
	Crankpin	Splash or Forced	1400–1800	10	500–750	0.5–1.5	0.001
	Wrist pin	Splash or Forced	1800–2200	5	500–750	1.5–2.0	0.001
Compressors	Main	Splash	250	30	300–500	1.0–2.2	0.001
	Crankpin	Splash	600	20	300–500	0.9–1.7	0.001
	Wrist pin	Splash	1000	10	300–500	1.5–2.0	0.001

IV—RECOMMENDED SHAFT HARDNESS FOR VARIOUS BEARING MATERIALS

Material	Hardness (Brinell) 70 F	210 F	Shaft Hardness (Min Brinell)	Load Capacity psi
Tin Bronze	60–75	60–70	300	4000–up
Phosphor Bronze	70–125	65–100	300	4000–up
Lead Bronze	40–70	40–60	300	4000–up
Copper–Lead	20–30	18–25	500	1500–2500
Lead-base Babbitt	14–22	6–14	120	800–1500
Tin-base Babbitt	17–27	8–12	120	800–1500
Lead–Tin Overlays	14–20	6–10	120	2000–4000
Aluminum-base Alloys	45–50	40–45	250	4000–up
Sintered Bronze	65–70	60–70	300	4000–up
Cast Iron	140–250	140–250	150	4000–up
Silver Plate	23–27	23–27	475	4000–up

TABLE V—INFLUENCE OF SURFACE ROUGHNESS ON FRICTION

Surface Finish (microin rms)	Coefficient of Friction		
	Mineral Oil	Mineral Oil with 2% Oleic Acid	Oleic Acid
Super (2)	0.128	0.116	0.099
Ground (7)	0.189	0.170	0.163
Ground (20)	0.360	0.249	0.195
Ground (50)	0.372	0.261	0.222
Ground (65)	0.378	0.230	0.238

VI—LOAD-CARRYING ABILITY VS SURFACE FINISH

Surface Finish (microin)	zN/p	Load-carrying Factor
150–200	2	1
40–60	0.6	3
20–25	0.25	9

Clearances

Proper clearance between journal and bearing depends on operating temperature, load, minimum oil-film thickness, friction loss, eccentricity of the bearing and shaft, and amount of oil flow. However, for practical purposes, a clearance of 0.001 x radius is usually satisfactory. Diametral clearance (difference between journal and bearing diameters) rarely needs be greater than 0.002 or less than 0.0005 in. Bearing clearances based on suggestions by

continued, next page

the American Standards Association are given in Table II.

Typical journal-bearing practices for various types of industrial machinery are provided in Table III. This table includes recommendations for maximum loading, lowest permissible zN/p ratio, recommended oil viscosity, length-to-diameter (L/D) ratio, and clearance (C/R) ratio.

Bearings and shaft materials

Metals selected for the bearing and the journal must operate well together. Some bearing metals work well with soft journals—others require hard journals. Tin-base babbitts, lead-base alloys and over-plated copper alloys can operate with an ordinary soft-steel shaft. Cadmium alloys demand a journal having a Brinell hardness above 250. Copper alloys and aluminum alloys require journals of over 300 Brinell hardness. Bronze does not operate well with soft steel, but does work well with cast iron or hardened steel. Babbitt metal, soft brasses and cast iron work well with soft steel.

Recommended minimum shaft hardnesses for 11 common bearing materials are listed in Table IV.

Surface finish

Surface finish of the shaft and bearing affect the friction and wear properties. The test data in Table V show effect of surface roughness, in microin, on coefficients of friction, using a straight mineral oil as a lubricant.

In the boundary area of lubrication, friction increases with roughness up to 20 microin, then remains fairly constant. Load-carrying ability is also affected by surface roughness, as shown by the analysis in Table VI.

This indicates that a surface finish of 20 to 25 rms carries 9 times the load of a finish of 150 to 200 rms.

LUBRICANT FACTORS

All of the design factors outlined above may influence the selection and performance of the lubricant. While meeting the infinite variety of conditions imposed by combinations of the above factors, a lubricant must perform the following functions:

- Maintain an unbroken film between metal surfaces to prevent excessive wear.
- Prevent excessive friction and its consequent heat, harmful to both equipment and lubricant.
- Absorb and carry away heat normally generated between moving surfaces and keep operating temperatures as low as possible.
- Remain stable and maintain its properties within allowable limits under severe operating conditions.
- Be economical in operation.

Temperature vs viscosity

Remember that viscosity is the most important single characteristic of a lubricant at work. Because viscosity varies with temperature, the important factor is not the viscosity of the oil at room temperature but at temperatures within the range encountered in the operating machine. An oil that thins out too much at high temperatures will not maintain a safe film.

Where high temperatures are unavoidable, a higher viscosity oil should be specified so as to deliver best lubrication despite this thinning-out process. On the other hand, winter temperatures require oils with lower viscosity and lower pour-point to maintain fluidity and prevent thickening to the point of inefficiency.

Power vs viscosity

Keep away from high-viscosity oils when loads are light. Lightly loaded mechanisms frequently have less power to spare and the excessive drag of a high-viscosity oil would absorb too much of the available power.

At the extreme opposite end of the load range are overloads. Where a bearing or gear set is overloaded in terms of its design so that the lubricant is overtaxed, a special lubrication study may be necessary. Check with a lubrication engineer or firm for recommendations. Costs of failures are too high to take chances.

Time-temperature factor

Almost any well-refined oil of correct viscosity will serve its purpose economically at normal temperatures. But as operating temperature rises, not only does viscosity decrease, but deterioration of the oil and deposits of oxidation products tend to increase rapidly unless the oil is designed to counteract these tendencies.

Oils for high-temperature applications are specially fortified against oxidation and deterioration. These are necessarily higher quality products.

What is a high temperature? Generally speaking, three temperature zones are encountered in lubrication:

Below 100 F, heat is no problem except in special cases, such as in refrigeration equipment where lack of heat requires special, dewaxed refrigeration oils to maintain a film of fluid oil under freezing conditions.

Between 100 F and 150 F requires stable, high-quality mineral oils or moderately fortified oils to maintain economical service life.

Above 150 F, temperature is a prime consideration. Maximum protection for the equipment over extended periods of time is of paramount importance. At such temperatures, well-refined inhibited oils, with their inherent high stability, are ideal long-term lubricants.

References: "Bearing Design & Application," Wilcox & Booser, McGraw-Hill, 1957; "Theory & Practice of Lubrication for Engineers," D D Fuller, John Wiley, 1956; "Bearing Lubrication Analysis," R R Slaymaker, John Wiley, 1955; "Plain Bearing Recommended Practice," Association of Iron & Steel Engineers, 1951.

For REPRINT of above article, just check 580 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE—For applications where it is not economical or feasible to provide oil to the bearing, see types of journal or sleeve bearings described in these articles:

Alloyed Plastics Give Oilless Bearing, May 25 '59, p 58—A new oilness bearing material has appeared with high load capacity and low coefficient of friction.

Additives Put Muscle into Sintered Nylon Parts, Sep 15 '58, p 86—Nylons fortified with graphite or molydenum disulfide additives for self-lubrication.

Nylon-clad Sleeve Bearings, Mar 3 '58, p 52—Nylon-11 acts as a cladding for metal sleeve bearings by providing a surface that takes high load and needs no lubrication.

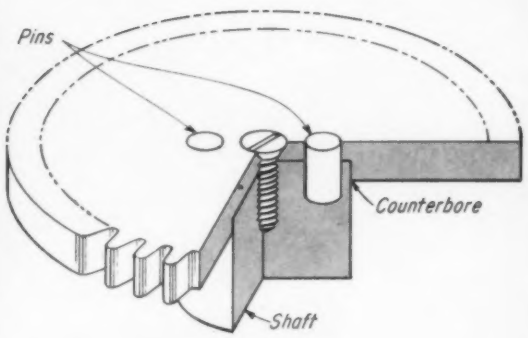
Experts Strip Mystery from Gas Bearings, Nov 23 '59, p 68—On-the-spot report on the First International Symposium on Gas-lubricated Bearings, held in Washington, DC.

—Nicholas Chironis

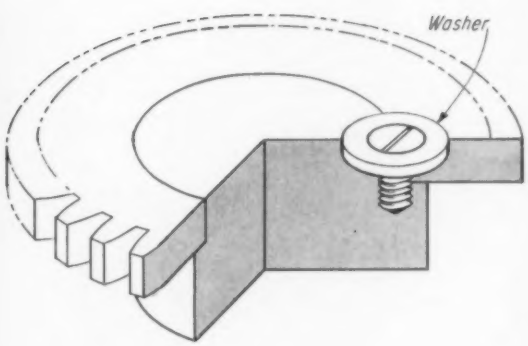
ATTACHING HUBLESS GEARS TO SHAFTS

Thin gears and cams save space—but how to fasten them to their shafts? These illustrated methods give simple, effective answers.

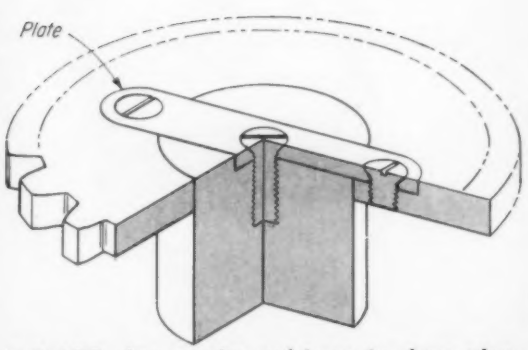
L KASPER, *consultant*
Philadelphia



1 COUNTERBORE with close fit on shaft ensures concentric mounting. Torque is transmitted by pins; positive fastening is provided by flathead screw.



2 TIGHT-FITTING washer in counterbored hole carries the radial load; its shear area is large enough to ensure ample strength.



3 PLATE gives greater resistance to shear when radial loads are likely to be heavy. When the gear is mounted, the plate becomes the driver; the center screw merely acts as a retainer.

continued, page 53

Here's 0.1° Sensitivity at a Competitive Price!

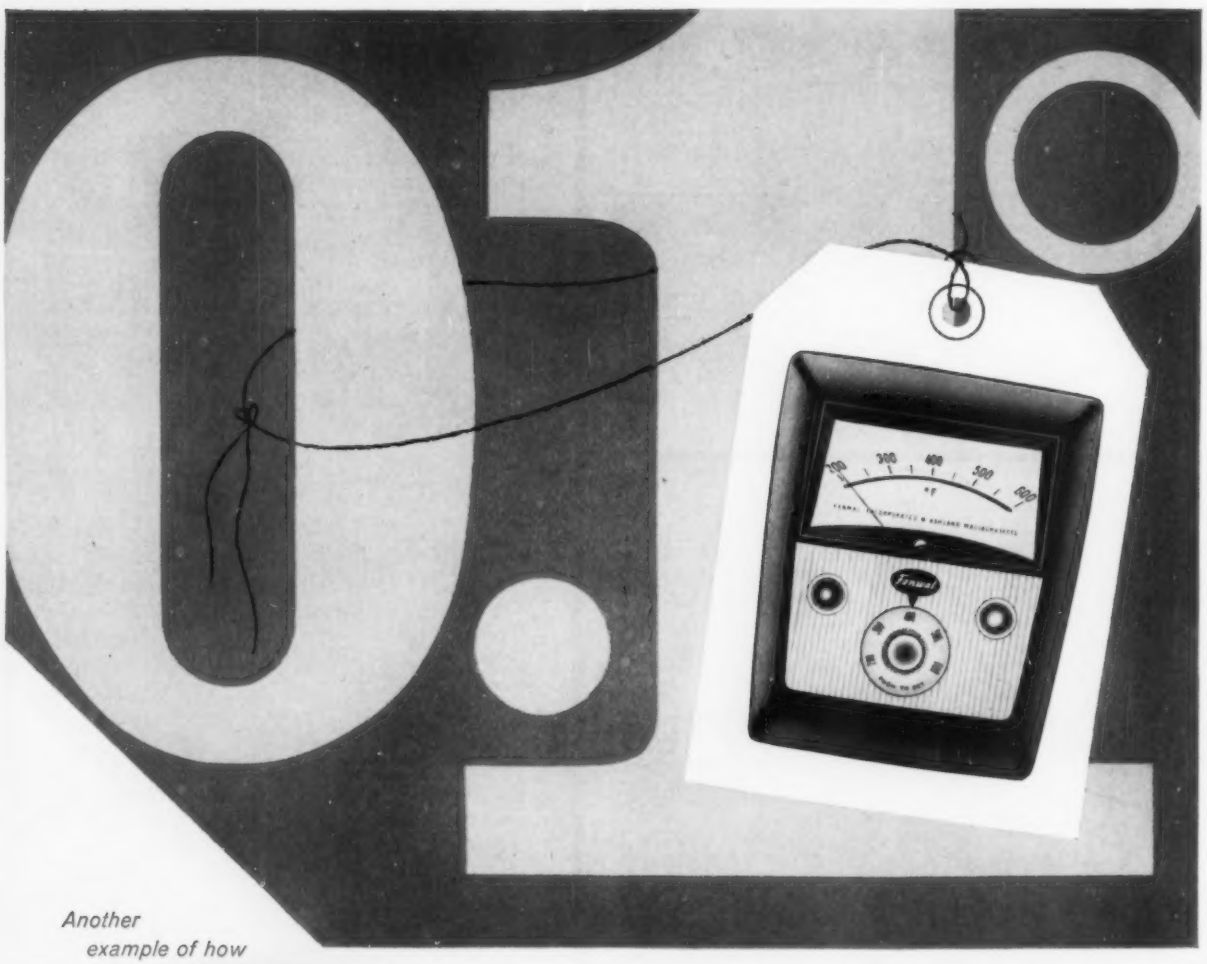
... Fenwal's New "561" Temperature Controller

The new "561" indicating controller responds to temperature changes of 0.1° or less! And is yours at a competitive price! These two features alone make it an instrument you should investigate... but there's more!

You can choose from five standard temperature ranges . . . within the span of −50 to 600°F. Furthermore, scales start and end within *your* ranges, permitting larger graduations, better legibility, easier readout. And control and indication are separate but simultaneous. *Should your indication fail the "561" will continue to control with complete accuracy.*

This precise instrument gives unvarying performance. Its indication and control will not vary with fluctuations of input voltage nor changes in ambient temperature. It offers the option of either ON-OFF or proportional control . . . has 10 AMP/120 VAC relay capacity. Smartly styled to complement modern industrial machines and interiors, *the "561" offers you all these extras at a competitive price.*

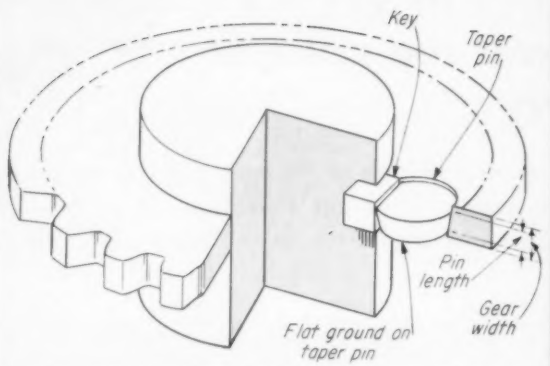
A Fenwal engineer will be glad to supply information on the "561", or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 21 Pleasant Street, Ashland, Massachusetts.



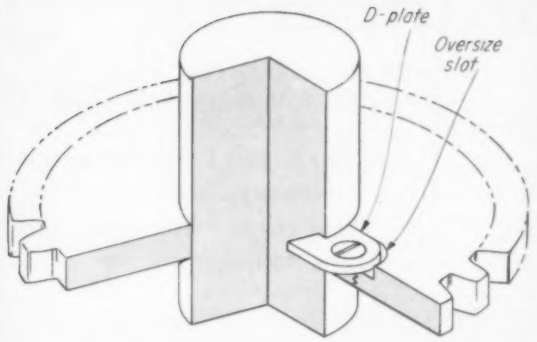
Another example of how

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

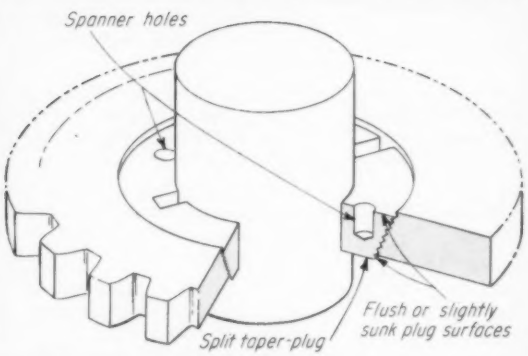
HUBLESS GEARS continued



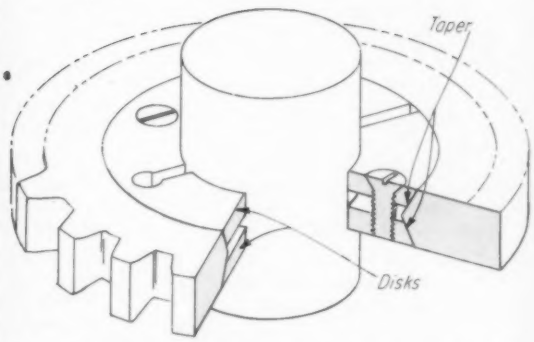
4 KEY AND FLATTED TAPER-PIN should not protrude above surface of gear; pin length should be slightly shorter than gear width. Note that this attachment is not positive—gear retention is by friction only.



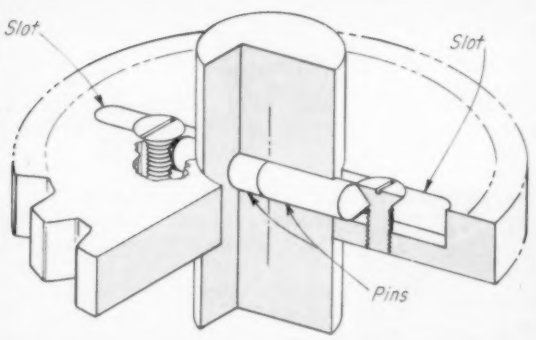
5 D-PLATE keys gear to shaft; optimum slot depth in shaft will depend upon torque forces and stop-and-start requirements—low, constant torque requires only minimum depth and groove length; heavy-duty operation requires enough depth to provide longer bearing surface.



6 TAPERED PLUG is another friction holding device. This type mounting should be used so that the radial load will tend to tighten rather than loosen the thread. For added security, thread can be lefthand to reduce tampering risk.



7 TWO FRICTION DISKS, tapered to about 5° included angle on their rims, are bored to fit the shaft. Flathead screws provide clamping force, which can be quickly eased to allow axial or radial adjustment of gear.



8 TWO PINS in radial hole of shaft provide positive drive that can be easily disassembled. Pins with conical end are forced tightly together by flathead screws. Slot length should be sufficient to allow pins to be withdrawn while gear is in place if backside of gear is "tight" against housing.

...these distributors

carry a broad line of BODINE 1/6 to .... 1/2000 horsepower MOTORS IN STOCK! ..for over-the-counter delivery

Your Bodine Distributor carries a well-rounded line of the more popular reducer and non-reducer motors... in the types, sizes, and ratings normally used by industry in your area. These motors are in stock, on the shelves, immediately available. Call your Bodine Distributor today.

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Jos. T. Fewkes & Company
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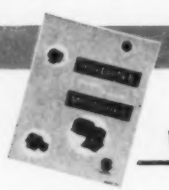
CANADA—Renold Chains Canada Ltd.
Offices in Clarkson, London, Montreal, Quebec,
Three Rivers, Vancouver and Winnipeg

Over 3500 standard built-to-order motors. See your Bodine representative.



Write for FREE Copy!

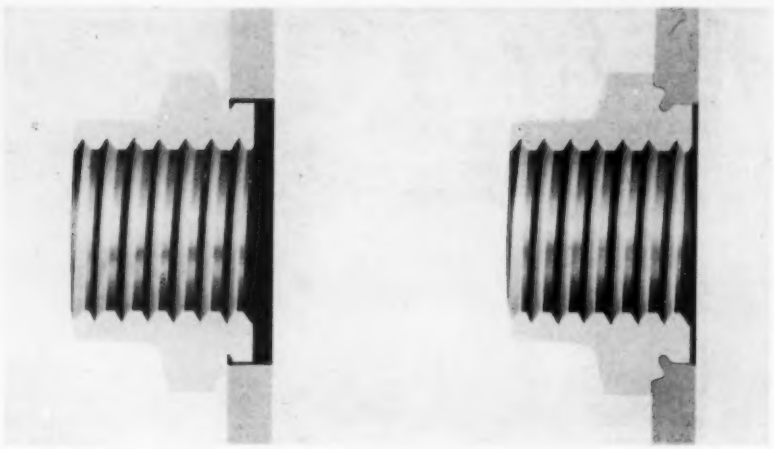
Bodine Motors are close-tolerance-machined. This means trouble-free operation . . . long life . . . low reject rates. The end result: a better motor, at a lower cost. Call your Bodine Distributor today. Bodine Electric Co., 2510 West Bradley Place, Chicago 18, Illinois.

BODINE fractional horsepower MOTORS

STOCK MOTOR bulletin . . . 12 pages of photos, cut-aways, drawings, tables, and charts describe 300 different Bodine Motors, 1/6 to 1/2000 hp. . . . most of which are carried in stock by your Bodine Distributor. Ask him for a copy of Bulletin "S-2," or consult your Sweet's Product Design file.

...the power behind the leading products

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



High-strength swage nut . . .

averages ½ the weight of similar fasteners, and carries assembly screw loads to 160,000-psi tensile strength. Has positive lock to prevent mating bolts from loosening under vibration. Spring action of three-side locking collar reduces thread dia and holds bolt securely wherever wrenching stops. Requires only one tool, placed in a press, for installation. When pressure is applied, nut displaces metal around edge of hole which forms retaining ring to anchor nut. Push-out and torque-out values are said to meet MIL-N-25027 requirements. Can be used in any sheet material (including steel, copper, Monel and aluminum) 0.20 in. thick and up, with hardness up to Rockwell C27. **Standard Pressed Steel Co, Jenkintown, Penna.**

Circle 300 on Reader Service Card

Magnetic memory drum . . .

presents recorded information when stationary as well as in motion. Suitable for program control of multiple machine operations. For application to machine tools, presents cutting coordinates on step-by-step basis, remaining stationary while tool completes a cut. At end of a cut, drum steps to next position, corresponding to end of next cut and signals new coordinates to machine. Coordinates are recorded as a series of parallel binary code words on sequential steps of drum. Unit has no amplifiers. Output into 1000 ohms is 1.5 v dc for a "one" reading; less than 30 milliv for a "zero" reading. Into cold-cathode matrix, drum can have output of 65 v ac for "one"; less than 2 v for "zero." Ten-channel, 2000-bit drum (200 discrete segments per channel) measures 26 x 14 x 14 in. Price: approx $300 per channel. **Consolidated Controls Corp, Bethel, Conn.**

Circle 301 on Reader Service Card

Controlled-pressure air column in regulator . . .

replaces adjusting screw and control spring used in standard units. Air column applies constant force on diaphragm and is governed by "pilot" regulator, operating at almost "no-flow" for prompt response, high airflow rate and accurate pressure control. Unit can be installed out of reach for regulation of inaccessible air lines. Any size regulator with desired pressure range can be used as the pilot. **Hannifin Co, Dept 126, 501 S. Wolf Rd, Des Plaines, Ill.**

Circle 302 on Reader Service Card

Aftercooler for small to medium air systems . . .

is available in capacities of 50 to 120 cfm free air. Lengths range from 30⅜ to 95½ in. over-all, with 4½-in. dia cooling chambers. Has noncorrosive copper coil, through which valve-regulated cooling water flows. Coil is attached to flanged head with flared connections and supported throughout its length by spaced baffle plates which direct airflow. Separated moisture decends by gravity to ball-float trap below, where it is automatically ejected without air loss. **James A Murphy & Co Inc, 1421 E High St, Hamilton, Ohio.**

Circle 303 on Reader Service Card

Permanent-magnet motor with variable pole . . .

reportedly never fails to start. L-shape pole arm is riveted onto rotor and is not magnetized. If rotor poles should stop on dead center, magnetism induced in variable pole arm by field coil starts rotor. Speeds range from 10 to 1/60 rpm. Available from stock in clockwise or counterclockwise rotation, 115 v, 60 c. Standard motor is rated at 20 in.-oz and high-torque model, 40 in.-oz at 1 rpm. **Lake City Inc, Sub Controls Co of America, Crystal Lake, Ill.**

Circle 304 on Reader Service Card

Bearing steels . . .

for high temperature structural components, include one alloy in which 4% molybdenum replaces 2% chromium in 440 C analysis. Other alloys contain 1% and 2% vanadium, with correspondingly

continued on page 56

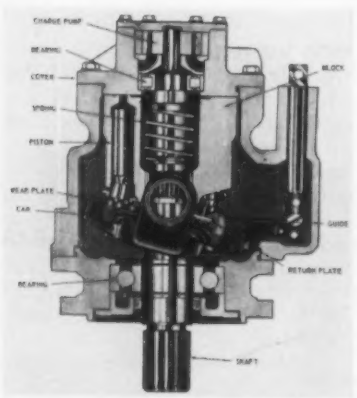
higher carbon contents. Said to exhibit improved hot-hardness properties and better resistance to wear, corrosion and oxidation than standard 440 C analysis. **Latrobe Steel Co, Latrobe, Penna.**

Circle 305 on Reader Service Card

Submicron-particle filter . . .

uses a porous plastic sheet with uniform submicron holes to trap particles down to 0.1 micron. Also removes bacteria from fluids. Membrane filter apparatus is disposable. Holder is available in stainless steel or nickel-plated bronze for pressures of 50, 100 and 500 psi. Price ranges from $195 for nickel-plated 50-psi unit to $550 for stainless steel 500-psi unit. Delivery within 30 days. **Gelman Instrument Co, 106 N Main St, Chelsea, Mich.**

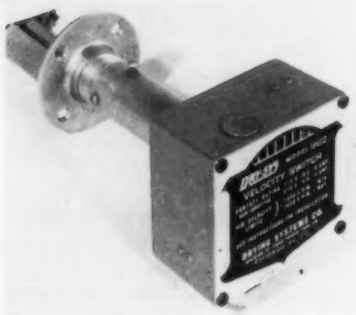
Circle 306 on Reader Service Card



Hydrostatic transmission . . .

for off-road mobile equipment, produces full torque at low engine speeds—even idle. Has infinitely variable speed ratio, always under operator's control, and maneuverability over soft ground, sand, or cinders, since operator can feed to wheels only that amount of power which can be absorbed by available traction. Transmission consists of variable displacement, axial-piston hydraulic pump, which is coupled directly to vehicle's engine, and a fixed-displacement hydraulic motor, which drives directly into differential. High-pressure hoses replace driveshaft, universals, gear changes and clutches. Motor's rotation speed and direction are determined by position of pump's variable cam. Has single control for both direction and speed. Displacement is stated at 4.5 cu in./rev; speed (at full cam angle), 3000 rpm; running torque, 56 ft-lb at 1000 psi; starting torque, 50 ft-lb at 1000 psi; temperature range, −30 to 200 F; hp rating at 2000 rpm, 60. **New York Air Brake Co, Starbuck Ave, Watertown, NY.**

Circle 307 on Reader Service Card



Velocity switch . . .

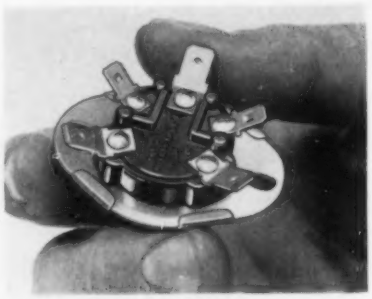
is actuated by air velocity in a duct and does not respond to static pressure or suction. Duct air cannot pass through switch, nor can external air pass into duct through switch. Primary action is magnetic, through a solid barrier. Responds to velocities as low as 1000 fpm (max air velocity is 7000 fpm). Contact rating is 8 amp at 115 v ac and 4 amp at 230 v ac. **Drying Systems Co, 1800 Foster Ave, Chicago 40.**

Circle 308 on Reader Service Card

Vibrating-reed relay . . .

remotely controls up to 10 separate switching functions, using tone-modulated RF or single-wire conductor. Each reed controls one function through small secondary relay and resistance-capacitance filter. One-oz unit reportedly has high bandwidth selectivity, making it interference-free. Produced in 30 to 3000-ohm coil resistances and impedances from 30 to 5000 ohms. Driving voltages vary from 1½ to 15 v ac. Reed contacts will pass up to 5 ma, and frequencies are within ±0.05%. Ten-channel unit is priced at $22.50. Units with 2, 4, 6 and 8 reeds also are available. **W S Deans Co, 8512 Gardendale St, Downey, Calif.**

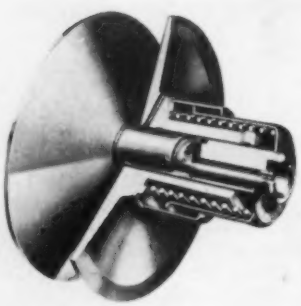
Circle 309 on Reader Service Card



Thermostat's internal heater . . .

creates own temperature or ambient inside unit and is used to lower thermostat operating point. Unit can be made to operate through wide temperature range by remotely controlling voltage on heater and to a narrow differential. Heater available between 250 ohms and 1 megohm. Unit, SPST or SPDT, is rated to 350 F at 25 amp resistive or to ½ hp at 120/240 v ac. **Therm-O-Disc Inc, Mansfield, Ohio.**

Circle 310 on Reader Service Card



Motor pulley drives . . .

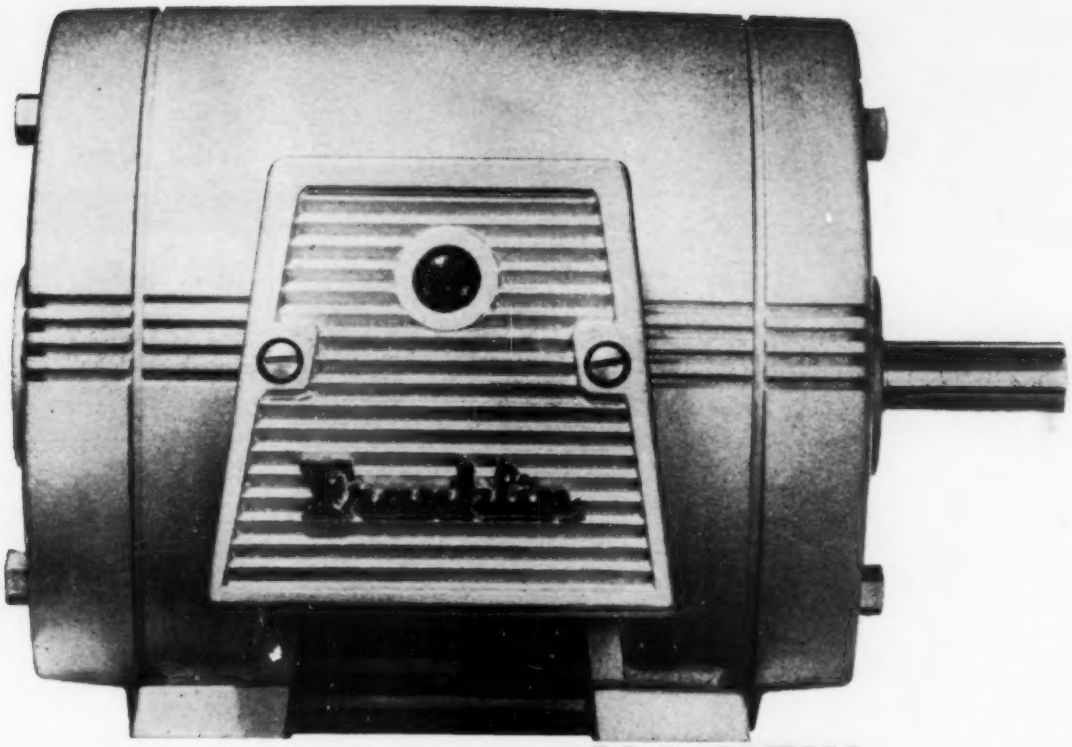
for variable-speed operations, are rated from 1 to 15 hp. Output speeds range from 2200 to 141 rpm, with a 3:1 speed variation utilizing 1750- or 1160-rpm motors. Have V-to-V drive transmissions. **Sterling Electric Motors Inc, 5401 Telegraph Rd, Los Angeles 22.**

Circle 311 on Reader Service Card

Magnetic-reed relay . . .

is less than half the conventional size. Coil measures ⅜ in. long x 7/16 in. dia. Over-all length with standard solder terminals is 1½ in. Comprises a magnetically actuated contact assembly inside actuating

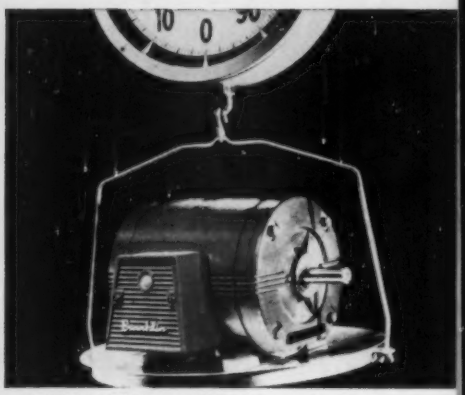
continued on page 60



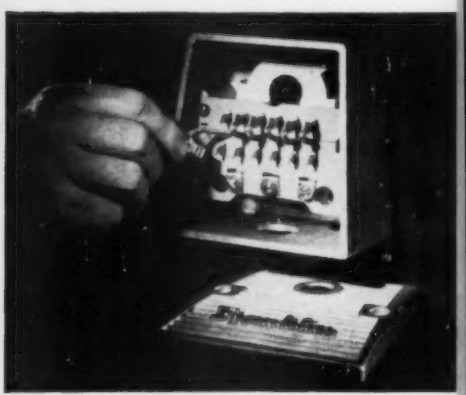
ALL NEW FRANKLIN STANDARD MOTORS WEIGH UP TO 30% LESS THAN ORDINARY INTEGRAL MOTORS

Read about this engineering accomplishment on the next two pages ... Also on the next page—news of a contest for design engineers only!!

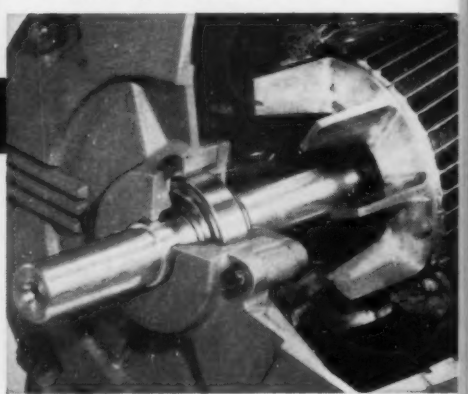
NEW!



ALUMINUM CONSTRUCTION of the new Franklin motor gives the designer terrific weight advantages, plus faster heat dispersion and freedom from rust and corrosion. Strong, too.



QUICK-CONNECT TERMINAL BOARD comes preconnected to your specified voltage. Eliminates time-consuming taping and wiring. And your customers can change the voltage in 1 minute flat!



PRELUBRICATED AND DOUBLE SHIELDED BEARINGS absolutely exclude all contaminants, eliminate the chief cause of motor bearing failure. Internal labyrinth seal keeps the grease in the bearings, out of the windings.

Franklin Integral Motors are made of Aluminum...

YET THEY'RE STRUCTURALLY STRONGER THAN COMPARABLE CAST-IRON MOTORS!

Here's news of a new, feather-weight motor you can apply *now* to your product.

Franklin Electric has designed an integral HP motor that gives you the light weight of aluminum . . . with a shock resistance greater than cast iron!

Aluminum frame, end-bells, rotor, and conduit box are combined to give you an average of *30% less weight* per motor rating.

You actually design weight *out* of your product by using this new, lighter motor. You'll need less bracing and support. And the Franklin lightweight is far easier to handle on your assembly lines. Less worker fatigue, faster assemblies. What's more, your shipping costs go down automatically with the over-all weight reduction!

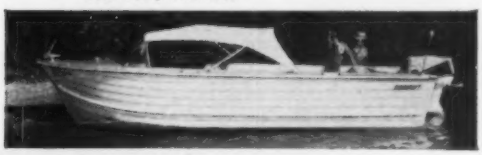
Aluminum has other advantages for you, too: greater thermal conductivity for cooler running, and a high resistance to rust and corrosion.

How many times could you have used these other Franklin features:

1. Pre-packed, double shielded bearings that absolutely exclude contaminants (chief cause of bearing failures in ordinary motors). There's an unusual labyrinth seal on the shaft that keeps grease in the bearings, not on the shaft. And a grease reservoir that practically eliminates the need for regreasing.
2. Quick-connect terminal board that arrives pre-connected to your specified voltage. No more taping and wiring. Terminal connectors make line connections in a matter of seconds.
3. Two-year guarantee from date of manufacture.
4. Inherent protector space *built-in* to the conduit box. The clean lines of this motor will stay clean. No add-ons.
5. Identical NEMA single and polyphase motor frame sizes. They're completely interchangeable, so you need carry no extra bases in stock.

And plenty more designer-requested features that can help you cut costs and increase the efficiency of your motor-driven product. For the complete story, just send in coupon below for a free, full-color brochure which explains this new motor line in detail. And while you're at it, enter the Franklin "Name the Aluminum Motor" contest explained below. Send in the coupon today.

Franklin® Electric Co., Inc.
BLUFFTON, INDIANA



Name the Aluminum Motor Contest... for Design Engineers only!

WIN A FULLY EQUIPPED STARCRAFT ALUMINUM BOAT AND EVINRUDE MOTOR!

Send your suggestion for a name for the all-new Franklin aluminum motor on the coupon at right. First prize—a 16 ft. Starcraft aluminum "Jupiter" runabout and a 40 h.p. Evinrude outboard motor. Twenty additional runner-up prizes of deluxe aluminum golf carts. Enter now, while the coupon is right in front of you. Here's all you have to do:

1. Send to Franklin Electric Company, Inc., your name suggestion, which reflects either a use or a feature of the motor. For example: OEM motor, Alumaline motors, etc. Send as many names as you please.
2. Prize winners will be chosen by an impartial panel of judges who are not employees of Franklin Electric Company, Inc.
3. Your entry must be in by February 28, 1961.
4. There's nothing to buy—just send your name suggestion.
5. That's absolutely all there is to it. In addition, your entry will automatically bring you a full-color informative brochure on the new Franklin aluminum motor.
6. Employees of Franklin Electric and its advertising agency are not eligible to participate as contestants. Contest offer not valid in states which prohibit such contests.

SEND YOUR ENTRY TO:
Franklin Electric Company, Inc.
Name-the-Aluminum Motor Contest
Bluffton, Indiana

Name _____ Title _____
Company _____
Address _____
City _____ State _____
Suggested name for the new Franklin motor:
_____ E

CIRCLE 59 ON READER SERVICE CARD

coil. Gold contacts are hermetically sealed inside a glass capsule in an inert gas atmosphere. This reportedly prevents contact contamination and makes for highly stable contact resistance through long service life. Standard contacts are SPST, normally open—rated 12 w resistive load, 0 amp max. Contact resistance is 50 milliohm max; breakdown voltage, 200 v ac (RMS) min. Coil power is a nominal 100 milliw, a min 50 milliw. Operate time is less than 1 millisec; release time, less than ½ millisec. **Magnecraft Electric Co, 3350X W Grand Ave, Chicago 51.**

Circle 312 on Reader Service Card

Pressure-molded Teflon sheets . . .

are of high density and available from stock in sizes up to 24 x 24 x 2 in. All surfaces are ground and corners sharp, allowing sheets to lie flat. **Fluorocarbon Co, 1754 S Clementine St, Anaheim, Calif.**

Circle 313 on Reader Service Card

Variable-pitch pulley . . .

originally designed for heating and air-conditioning uses, is suitable for applications where optimum operating speeds cannot be mathematically determined. Operates similar to one-piece pulley and reportedly cannot slip out of adjustment. Precise adjustment in small increments is accomplished by two splined grooves, 180° apart, which interrupt external threads. Setscrew in female member provides positive register. Max speed variation is 30% in five turns, and static and dynamic balance is held to 0.125 in.-oz. Handles 3L, 4L and 5L belts and is available in ½-, ⅝- and ¾-in. bores. **Tann Corp, 3750 E Outer Dr, Detroit 34.**

Circle 314 on Reader Service Card

Ratchet-free stepper motor . . .

has low radiated magnetic field and can be operated with windings continuously energized in static condition or pulsed at rates up to 2400 steps per min. Suitable for high-speed stepping applications where pulse power is limited. Withstands 100-g shock for 7 ms, as well as acceleration of 10 g. Operates from —66 to 185 F, delivering 80 pulses per sec on pulse requirements of 12.5 millisec. Positive magnetic detenting occurs at each of 12 angular rotor positions even under severe vibration and whether or not coils are energized. Although motor is unidirectional, small size permits two units to be combined with a differential for bidirectional operation. Rated at 27 v dc with a rotor step angle of 30° per cycle. Load is stated at 0.2 oz-in. at 68 F. **A W Haydon Co, Waterbury, Conn.**

Circle 315 on Reader Service Card

Two-stage hydraulic pump . . .

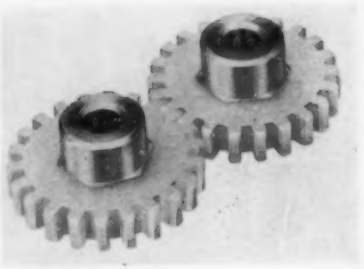
delivers from 600 cu in. per min. at 100 psi to 50 cu in. per min. at 10,000 psi. Driven by a universal motor, unit comprises a gearpump for low-pressure stage and five-cylinder axial-piston pump (supercharged by gearpump) for high-pressure stage. Reservoir capacity is 2 gal., with 1¼ gal. of usable oil. Standard motor is 1⅛ hp, 12,000 rpm 60/50 c, ac or dc, while motors for either 115 or 230 v are available. Over-all dimensions are 10¾ x 12⅝ x 17½ in.; weight, 45 lbs. **Owatonna Tool Co, 727 Cedar St, Owatonna, Minn.**

Circle 316 on Reader Service Card

Stainless socket screws . . .

have min tensile strength of 125,000 psi at room temperature. Other room-temperature ratings: 75,000 psi shear strength and 40,000 psi tension-tension fatigue endurance limit. Made of 304 austenitic material, hardened through cold working, with controlled forged burr-free heads. Operating range is —300 to 800 F; magnetic permeability, under 1.2. At 800 F with initial stress of 65,000 psi, residual stress after 50 hr was found by stress-relaxation tests to be 55,000 psi. Available in sizes #8 through ⅜-in. dia in both coarse- and fine-thread series. **Standard Pressed Steel Co, Jenkintown, Penna.**

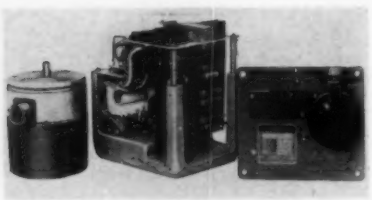
Circle 317 on Reader Service Card



Nylon cut gears . . .

have hexagonal metal hubs, inserted when gear blanks are molded. Hub is locked radially by its hex shape and axially by a channel cut around its face. Said to provide max resistance to shock, torsion and vibration. Since gears are cut with hub molded in blank, teeth and shaft concentricity reportedly tops molded tooth gears and others with hubs added after teeth are cut or molded. Strength is said to be same as that for metal gears, using Lewis formula which assumes that entire load is born by a single tooth. **Climax Metal Products Co, 863 E 140th St, Cleveland 10.**

Circle 318 on Reader Service Card



Position control . . .

provides resolutions of one part in 30,000 or better. Comprises a position sensor (or combination actuator and sensor), solid-state printed-circuit amplifier and digital-readout position setter. Amplifier can drive rotary or linear actuator. Output can be solid state or from relays. Crossover circuit provides rapid traverse and transfer to slower speed as preset position is approached. In machine-tool application, setting to 0.001 in. is provided over 30-in. travel. Systems with higher or lower accuracies are suitable for valve positioning, variable-speed drive control and process or programing control. **Jordan Controls Inc, 3235 W Hampton Ave, Milwaukee 9.**

Circle 319 on Reader Service Card

Commutated sampling system . . .

uses 12 transducers as sensors and provides readouts from any or all 12 consecutive remote points. Readout is through a digital display unit, and output is ±10 v dc. Measurement time intervals from each source are 1 to 2 sec, with stepping switch

continued on page 64

Another Tinnerman Original...

Nut-in-a-cage eliminates welding or staking...
SPEED GRIPS® hold themselves on panels!

Wherever you require a heavy-duty, multi-thread, self-retaining fastener, a Tinnerman SPEED GRIP Nut Retainer answers the need, holds down assembly costs.

SPEED GRIPS snap into place... some into panel holes... others over panel edges. No special tools or skills required. Spring-steel fingers grip the panel, yet let the nut float to compensate for normal panel-hole misalignment. Welding, staking and clinching are eliminated. SPEED GRIPS can even be applied after panels have been finished, avoiding paint-clogged threads.

SPEED GRIPS are available in a wide range of sizes and types, including front-mounting nut and bolt retainers for hard-to-reach or blind locations.

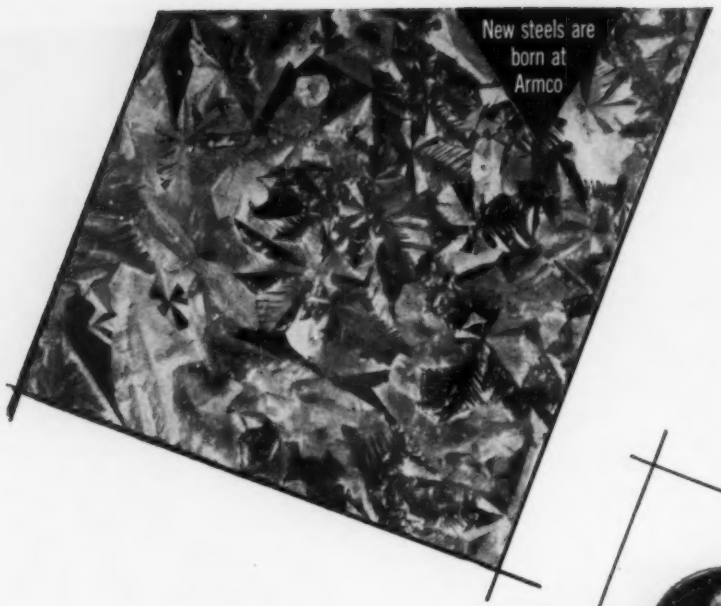
See your Sweet's Product Design File, section 8-T for data on these and other SPEED NUT Brand Fasteners. Your Tinnerman representative has complete information and samples. If he isn't listed under "Fasteners" in your Yellow Pages, write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

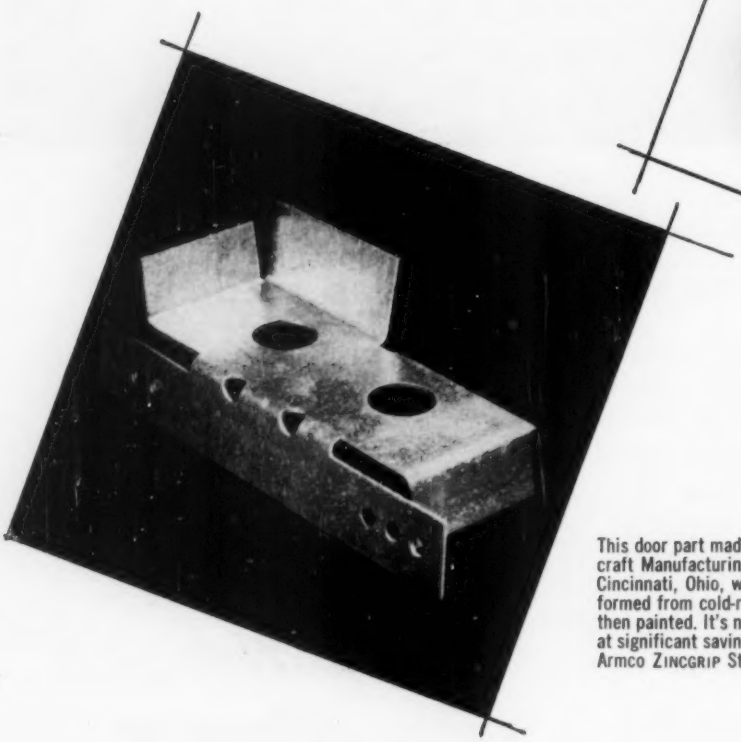
TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S.A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.



Coating on



This door part made by Steelcraft Manufacturing Company, Cincinnati, Ohio, was previously formed from cold-rolled steel, then painted. It's now fabricated, at significant savings, from Armco ZINCGRIP Steel.

ZINCGRIP gives products durable protection at average cost of about 2⅓¢ per square foot

Can you match this with painting or plating?

Unseen structural parts are often protected from corrosion by painting or plating cold-rolled or hot-rolled steel. Yet with Armco ZINCGRIP® Steel, you can give your products the durable protection of a full-weight two-side coating of zinc at an *average cost of about 2⅓ cents per square foot.* Important cost savings are realized daily by manufacturers who take advantage of this economical protection.

Severe fabrication is no obstacle. You can work mill-coated ZINCGRIP to the limit of its ductile steel base. The tight zinc coating will not flake or peel.

If you paint or plate for protection from corrosion, it will pay you to investigate Armco ZINCGRIP Steel. Let us help you compare your costs for a painted or plated steel part with costs for the same part made from durable ZINCGRIP. Just fill in and mail the coupon.

Armco Division • Armco Steel Corporation
1171 Curtis Street, Middletown, Ohio
So that I can check savings with Armco ZINCGRIP—
☐ Send me your Application Data Bulletin
☐ Have an Armco Representative call

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

Steel

Use this label to identify your products made of strong, durable steel.

Check these cost comparisons

Steel Thickness	Cost of* ZINCGRIP Coating c/sq. ft. of sheet	Typical** Cost of Painting c/sq. ft. of sheet	Savings with ZINCGRIP c/sq. ft.
.025	1.83c	3.25c	1.42c
.050	2.72	3.25	.53
.075	2.51	3.25	.74
Average . . .	2.35c	3.25c	.90c

*Coated both sides **Painted both sides

Computations based on coils 24" to 36" wide. ZINCGRIP coating costs are additional costs beyond price of cold-rolled steel. Due to variations between thicknesses, cost of zinc coating in table varies somewhat even though it's the same full-weight coating. Paint costs are figured on typical dip-painting or flow-coating methods and include cost of metal preparation, paint, labor and overhead of painting operations. Some paint costs are lower than these; many are more.

ARMCO **Armco Division**

provided to increase this to 12 readouts per sec. Frequency response is down 3 db at 300 cps, while ripple content is 50 mv at full output. In null position, ripple in output is reduced to 15 mv. Bridge balance linearity is 0.25%, and system gain (dc/ac from bridge) is preset to 100. **Crescent Engineering & Research Co, 5440 N Peck Rd, El Monte, Calif.**

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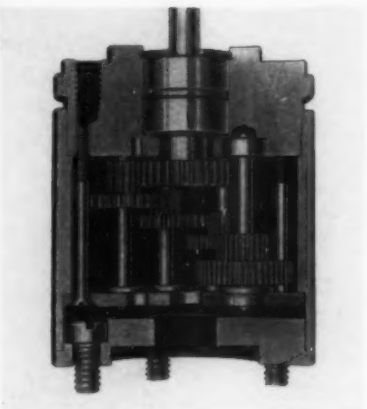

Gearheads for servomotors . . . are said to be 95% efficient. Available in size 11 frame and to most ratio, physical and mechanical specifications. Have ABEC-7 ball bearings throughout, shielded output bearings and hardened and passivated gears and pinions. **Planet Instrument Inc, 616 S Lafayette St, Fort Wayne, Ind.**

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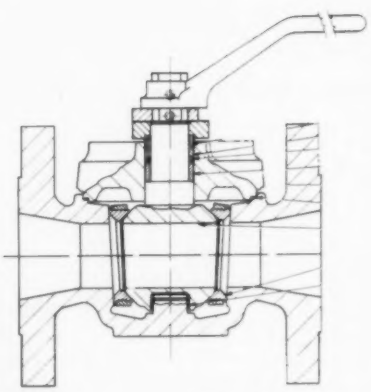

Ball valve accessible from top by removing bonnet flange. Thus, maintenance can be accomplished without taking valve from line. Seats can be adjusted by tightening two hex nuts on bonnet. Design differs from floating ball construction in that ball is fixed between top and bottom guides, while "floating" seats are held against ball for tight sealing. A 90° turn opens and closes 150 psi

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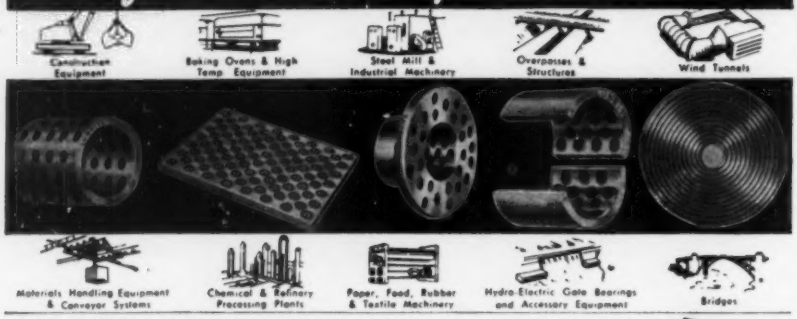
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valve. Made of carbon or 316 stainless steel with Teflon seats and seals in 1-, 1½-, 2-, 3-, 4-, 6- and 8-in. dia. Prices start at $42.20. From stock. **Hydromatics Inc, 5 Lawrence St, Bloomfield, NJ.**

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Warning horn . . .

continuously generates a variable frequency, high-amplitude tone until voltage is removed. Visual indicating lamp can be supplied. Operates at 18 to 32 v dc, with 115-v, 60-c voltage available on request. **Spec-Technology Inc, 13901 Saticoy St, Van Nuys, Calif.**

Circle 323 on Reader Service Card

Steady-state switches . . .

have 25-amp current ratings and reportedly handle inrush currents up to 75 amps without affecting accuracy, or repeatability. UL ratings are 25 amp at 125 or 250 v ac; 1 hp at 125 v ac; 2 hp at 250 v ac; and 750 v-amp at 125 or 250 v ac. Operating force is 14 to 22 oz; release force, min 10 oz; and differential travel, from 0.002 to 0.0075 in. Priced at $1.95 in quantities of 1 to 9. **Micro Switch Div, Minneapolis-Honeywell Regulator Co, Freeport, Ill.**

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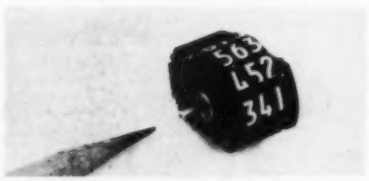

Internal pinion counter . . .

allows use of larger number wheels. Unit has 0.220-in. high figures in 0.305-in. opening. Static torque is 1.0 oz-in. over —67 to 212 F. Actual counting is performed by 0-9 unit wheels which register 10 counts per revolution. Speed is 750 rpm intermittent and 300 rpm continuous. **Veeder-Root Inc, 70 Sargeant St, Hartford 2, Conn.**

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Adjustable time-delay relay

has four different timing ranges, including: 50 to 500 millisec; 0.05 to 5 sec; 2 to 25 sec; and 5 to 60 sec. Unit has standard automatic relay and adjustable time circuit combined with two-stage transistor amplifier. Relay can be reset in less than 20 millisec by means of external pushbutton switch. Power requirements are from 18 to 32 v dc at 10 milliamp nominal. Repeatability is 1% short term at constant voltage and temperature; 5% short term at extreme voltage and temperature; and 10% long term. Four con-

continued on page 67

Maxitorq
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With these performance-proved units, you can save time and money in designing and building clutches and brakes exactly tailored to the requirements of your application. At the same time, you can be sure that they will equal the performance and smooth operation of proved MAXITORQ clutches and brakes. DISC-PACS are simply the "heart" of a clutch or brake . . . the discs, separator springs, and locking plate . . . supplied as a complete self-contained unit for the convenience of design engineers and equipment builders.

Produced in a full range of sizes and capacities from ¼ h.p. to 15 h.p. Bulletins available on other MAXITORQ products: Floating Disc clutches and brakes, Electric clutches, Overload Release clutches, low-cost Single Disc clutches, and clutch or brake friction discs. Write Dept. PE.

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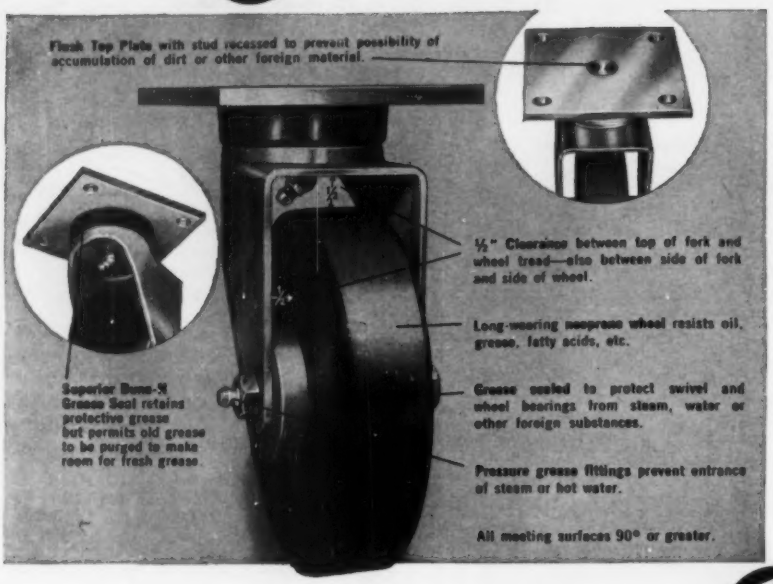
RESISTS CORROSION

J&J Grease Seal Caster


Flush Top Plate with stud recessed to prevent possibility of accumulation of dirt or other foreign material.
½" Clearance between top of fork and wheel tread—also between side of fork and side of wheel.
Long-wearing neoprene wheel resists oil, grease, fatty acids, etc.
Grease sealed to protect swivel and wheel bearings from steam, water or other foreign substances.
Pressure grease fittings prevent entrance of steam or hot water.
All meeting surfaces 90° or greater.
Superior Buna-N Grease Seal retains protective grease but permits old grease to be purged to make room for fresh grease.

. . . designed to the exacting specifications of the Bakery Industry Sanitation Standards Committee

Grease sealed throughout to protect the swivel and wheel bearings from wet floor conditions or the effects of steam or hot water cleaning. Pressure grease fittings prevent entrance of moisture, dirt, lint, etc. Long wearing "neoprene" wheel resists oil, grease, and fatty acids. Easy to clean, with wide wheel clearances. Designed for 200# (per caster) load area. Top plate is standard 4″ x 4″ with 3″ x 3″ hole spacing.

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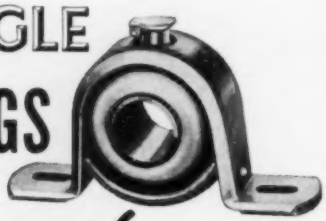
TRIANGLE BEARINGS with *Engineered* INDIVIDUALITY

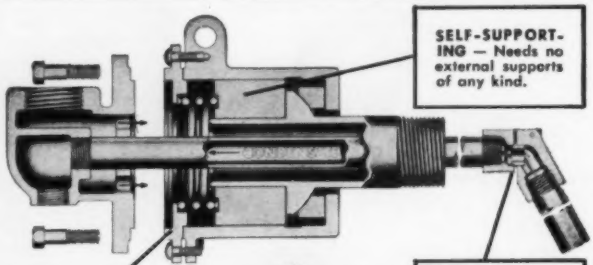


Triangle fits the bearing to the application. Whether you can use a standard, like the Pillow Block above, or need a special such as the Pedestal or Clamshell Bearings shown below, your particular bearing problem receives the individual attention best assuring cost reductions — quality improvements.

SELF-ALIGNING . . . SELF-LUBRICATING SLEEVE-TYPE PILLOW BLOCKS

The widest selection of mountings available — functionally designed, efficiently produced. Experienced sales engineers available to help you anywhere. Phone or write for descriptive literature.

TRIANGLE MANUFACTURING CO.
730 Division St. Oshkosh, Wisconsin


SELF-SUPPORTING — Needs no external supports of any kind.
ASSEMBLY PLATE — Holds internal parts in position when head is removed.
SYPHON ELBOW — Permits use of straight pipe for syphon. Can be inserted or withdrawn right through the joint.

Johnson Rotary Joint with SYPHON ELBOW

Johnson Joints represent the best way industry has yet found to get steam or liquids into rotating rolls and cylinders. They are completely packless, need no lubrication or adjustment. The Type SBP shown gets steam in, condensate out, through the same head. Other types available for through flow service, in sizes to meet all operating needs. ***WRITE FOR COMPLETE INFORMATION.***

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tact arrangements are available, with contacts rated at 3 amp, 115 v ac and 29 v dc, noninductive. General Automatic Corp, 111 33rd St, Union City, NJ.

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Woodchip material . . .

replaces wood wherever lightweight curved or contoured shapes are needed. Consists of wood chips (plus flake surface to cover chips when finish is desired), chopped fiberglass and polyester resin. Said to offer approximately the same fracture strength as hard maple and to hold nails, tacks, staples and screws better than wood. Specific gravity approaches 1.0 when material is molded at pressures between 300 and 500 psi. Can be molded in same way as fiberglass, masonite or wood flour. Gisholt Machine Co, 1245 E Washington Ave, Madison 10, Wis.

Circle 327 on Reader Service Card

Component hangers . . .

are available in two heights and wide bore size range to fit standard rotating components. Also available in blank state for non-standard size components. Made of aluminum alloy castings, finished in black anodize. Sterling Precision Corp, Component Div, 5 Sintsink Dr, Port Washington LI, NY.

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Regulated power-supply kit

has fully variable dc plate voltages from 0 to 400 v at 150 ma max. Also provides bias voltages from 0 to 150 v at 2 ma and three 3-amp ac filament outputs (two at 6.3 v and one at 12 v). Output variation is less than ¼ of 1% (or 0.3 v, whichever is greater) from zero to full load. Ripple is less than 0.003 v (RMS) and internal impedance, less than 10 ohms from dc to 1 mc. Power source is 117 v ac, ±10%, and power requirements, approx 160 w. Kit is priced at $69.95; factory-wired, ready-to-operate unit, $99.95. PACO Electronics Co Inc, 70-31 84th St, Glendale 27, LI, NY.

Circle 329 on Reader Service Card

DESIGN LITERATURE

Technical Writing Techniques for Engineers

JOSEPH RACKER. Prentice-Hall Inc, Englewood Cliffs, NJ. 6 x 9, 234 pp. $6.95.

There is some help in this book for the engineer-author, but its contents are aimed more at that modern-day specialist, the so-called "technical writer" who puts out handbooks, manuals and the like. This may explain why the book doesn't deal much with the many elements of effective writing. And one of its fotmulas, "Start writing—anything concerning the subject —and then keep going" would make the experienced writer smile wryly: It's not that simple. But the book does have strong points. One is its details on the proper handling of sketches and other illustrative material. Another: though the book lacks an index, almost half of its pages are devoted to eight valuable glossaries—Air Force Terms, Automation Terms, Computer Terms, Electrical and Electronic Terms, Guided Missile Terms, Radio and Radar Navigation Terms, Space Technology Terms, Transistor Terms.

—WG

Off-the-road Locomotion

M G BEKKER, The University of Michigan Press, Ann Arbor, Mich. 6 x 9, 220 pp. $10.

This book offers systematic research on the self-propelled vehicle as a unit in relation to environmental terrains. The author demonstrates how predictions can be made of vehicle performance and design parameters and discusses soil and snow mechanics, tracks, wheels and tires, as well as general factors associated with vehicles at assumed optimum performance. Important developments in industry and education are described to support the contention that automotive research can remain vital only if it is broadened to include theoretical as well as design analysis.

Welding Metallurgy

ARTHUR L PHILLIPS. American Welding Society, 33 W 39th St, New York 18. 6 x 9, 114 pp. $2.

This booklet, a reprint of a chapter from the Welding Handbook, is a short comprehensive text on welding metallurgy of ferrous and nonferrous metals. It discusses such fundamentals as properties and structure of the base metals and changes caused by welding heat. Valuable because it also tells what causes weld failures and what characteristics in the metal affect its weldability.

Welding metallurgy of these specific metals are covered in detail: carbon, low-alloy and stainless steel, nickel, copper, aluminum, magnesium, titanium and their alloys.

Other Books of Interest

Management Guide for Preventive Maintenance

B T Lewis, W W Pearson. John F Rider Publisher Inc, 116 W 14th St, NY 11. 5½ x 8½, 64 pp. $1.25.

On Reissner's Theory of the Bending of Plates

NASA TT F-27. A L Goldenveizer. National Aeronautics & Space Administration, Washington, DC. 8 x 10¼, 16 pp. 50¢.

RCA Photosensitive Devices and Cathode-ray Tubes

Radio Corp of America, Electron Tube Div, Harrison, NJ. 8⅜ x 10⅞, 36 pp. 50¢.

Damping of Rectangular-plate Vibrations

PB 161755. T S Lundgren, C C Chang, Y C Whang. Office of Technical Services, Washington 25, DC. 8¼ x 11, 20 pp. 75¢.

ABSTRACTS FROM THE LITERATURE

Electrical-system Transients

With the advent of solid-state devices and their susceptibility to destruction from transient impulses, there has been renewed interest in the subject of interference voltages. In this article, methods of controlling the coupling of transients into sensitive circuits are described.

"Electrical System Transients and Sensitive Circuit Control," T. B. Owen, Douglas Aircraft Co, AIEE Paper 60-1029. AIEE, 33 W 39th St., New York 18.

Magneto-thermionic Power

A design concept is presented which, under certain conditions, improves the efficiency of thermionic generators. The proposed concept envisages the application of a magnetic field perpendicular to the elec-

continued on page 68

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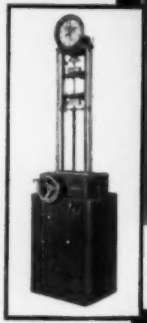

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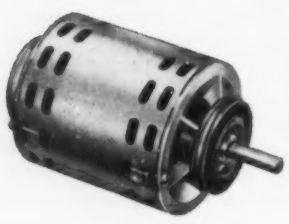

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trode surface. This applied field counteracts the adverse effect of the self-induced transverse magnetic fields present in large thermionic generators. In addition, the applied magnetic field may be used as a modulating device in order to generate an alternating current.

"Magneto-Thermionic Power Generation", A. Schock, Republic Aviation, Electrical Engineering, Dec '60, Farmingdale, N. Y.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 70.

UNIVERSAL JOINTS—Catalog J-1960, 220 pp. Discusses characteristics of single joints and assemblies; critical speeds; and torque capacities of round steel tubes. Contains dimensional drawings and specifications tables for a wide size range. Mechanics Universal Joint Div, Borg-Warner Corp, 2020 Harrison Ave, Rockford, Ill.

Circle 350 on Reader Service Card

TUBE FITTINGS—Catalog TF-1060, 24 pp. Contains illustrated specification tables covering over 100 tube fittings and accessories. Cutaway drawings shows O-ring seal adaptability in several complex design or maintenance situations. Lenz Co, 3301 Klepinger Rd, Dayton 1, Ohio.

Circle 351 on Reader Service Card

LOCKNUTS—Brochure GE-8067A, 16 pp. Illustrates and tabulates dimensions of automation grades; flange; and regular, thin and heavy hex collar styles. Also covers lock nut operating principles; results of torque-tension tests; max assembly torques; and proof load, tensile strength and hardness requirements of bolts. Federal Screw Works, 3401 Martin Ave, Detroit 10.

Circle 352 on Reader Service Card

MACHINING, FORMING, PROCESSING PLASTICS—Catalog, 216 pp. Covers dielectric ratings, tensile strengths, hardness, deformation, moisture and water resistance, linear expansion and contraction characteristics of Teflon, Kel-F, nylon styrene, epoxies and laminates. Also contains machining and forming instructions for rods, tubes, sheets, gaskets, etc. R. S. Hughes Co Inc, 4515 Alger St, Los Angeles 39.

Circle 353 on Reader Service Card

CASTERS AND WHEELS—Catalog 26, approx 62 pp. Outlines performance, load

ratings and applicable floor surfaces for swivel and rigid casters and wheels made of polyurethane elastomer, canvas cushion, formica, molded canvas, rubber, steel and iron. Thirty-four models are pictured. Divine Brothers Co, 200 Seward Ave, Utica, NY.

Circle 354 on Reader Service Card

PRE-TENSED SHEETMETAL STRUCTURES—Manual, 48 p. Describes and illustrates physical details of structural components; construction ideas for typical installations; assembly and layout plans; and materials needed for specific structures. Lindsay Div, Dept D60, International Steel Co, Evansville 7, Ind.

Circle 355 on Reader Service Card

POLYSTYRENE, POLYETHYLENE RESINS—Brochures, 4 and 6 pp. Properties of three polystyrene series and 21 injection-blow-molding resins are tabulated. Latter publication discusses applications for each polyethylene. Rexall Chemical Co, P O Box 37, Paramus, NJ.

Circle 356 on Reader Service Card

INDUCTION AND SYNCHRONOUS MOTORS—Bulletin 1024, 12 pp. Covers rated torques and types of duty for low- and high-slip ac induction motors and discusses performance of constant speed synchronous designs. Fairbanks, Morse & Co, Electrical Div, 303 N Henderson, Freeport, Ill.

Circle 357 on Reader Service Card

V-BELTS—Bulletin M-201, 8 pp. Gives specifications and graphically illustrates advantages of straight sidewall construction of belts for heavy and light duty, short and long centers. Manhattan Rubber Div, Raybestos-Manhattan Inc, Passaic, NJ.

Circle 358 on Reader Service Card

SEAL AND GASKET SILICONE RUBBER—Data sheet, 1 pp. Discusses swell, low and high temperature characteristics, shore hardness and molding and extruding process adaptability of silicone polymers which are resistant to fuels and oils. Stillman Rubber Co, 5811 Marilyn Ave, Culver City, Cal.

Circle 359 on Reader Service Card

MILITARY TERMINAL BOARDS—Bulletin 61-3, 8 pp. Offers electrical, mechanical specifications and dimensional drawings of 15 models. Kukla Electric Corp, 633-643 S Fulton Ave, Mt Vernon, NY.

Circle 360 on Reader Service Card

METAL HOSES—Catalog 539, 8 pp. Details pressures, working temperatures and installation methods for carbon and stainless steel connectors. Pictures 16 stand-

continued on page 70

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SELF-LOCKING BOLTS, SCREWS – Bulletin, 4 pp. Treats design characteristics, max torque, min breakaway, temperature and strength data. Also outlines results of tensile and fatigue tests and illustrates 18 head and point styles. Long-Lok Corp, 2601 Colorado Ave, Santa Monica, Cal.

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PHOTOGRAPHIC DATA-PROCESSING EQUIPMENT–Brochure, 20 pp. Explains operation of 10 instruments, including rapid film-processing cameras, automatic film titling equipment, X-ray cinefluorography cameras, and device for measuring bacteria content of atmosphere. Photomechanisms Inc, Huntington Station, LI, NY.

Circle 363 on Reader Service Card

COLD-HEADED FASTENERS – Brochure 10a, 8 pp. Describes and depicts cold-heading, giving formula for determining whether or not a part can be upset by process. Catalogs special and standard screws, bolts, nuts, pipe plugs and other threaded products. Elco Tool & Screw Corp, 1121 Samuelson Rd, Rockford, Ill.

Circle 364 on Reader Service Card

RESET TIMERS–Folder G-1681, 4 pp. Traces electrical ratings of rear- and panel-mounted models. Includes dimensional drawing, six circuit diagrams and sketches of basic unit and its 12 variations. Haydon Div, General Time Corp, 245 E Elm St, Torrington, Conn.

Circle 365 on Reader Service Card

DIALS–Catalog 9, 40 pp. Illustrates and gives specifications for 22 disk dials that range from 2 to 6 in. dia. Also covers dial rings, drum dials, drum and disk verniers, knobs and hubs. Ackerman Engravers Inc, 458 Broadway, New York 3.

Circle 366 on Reader Service Card

HIGH-VOLTAGE POWER SUPPLIES –Bulletin series 701, 2 pp. Pictures and presents specifications for six units in a 40 to 40,000-v output line. AMP Inc, Harrisburg, Penna.

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COATED GLASS FABRICS–Brochure, 6 pp. Discusses and illustrates epoxy and varnish-coated glass products; standard and commercial grades; and yellow varnished glass fabrics for electrical applications. Includes tensile and electric strength and thickness data. Irvington Div, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6.

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INDUSTRIAL PUMPS–Bulletin 1, 8 pp. Contains size, capacity, differential pressure, viscosity and temperature data on power driven and variable capacity pumps. Also covers proportioning systems; strainers; and hand, truck, aluminum transporter and liquefied gas pumps. Blackmer Pump Co., 1809 Century SW, Grand Rapids, Mich.

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PUSHBUTTON SWITCHES – Data sheet 182, 2 pp. Lists contact arrangements and electrical ratings of miniature DPDT units with two-color indication. Micro Switch, Div Minneapolis-Honeywell Regulator Co, Freeport, Ill.

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HIGH-HEAT ALUMINUM PAINT – Bulletin 1206, 3 pp. Discusses paint's formulation with silicone resin solution; where and how to use it; and its reactions to severe temperature and atmospheric conditions. Speco Inc, 7308 Associate Ave, Cleveland 9.

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DECAL NAMEPLATES – Brochure, 4 pp. Tabulates descriptions, designs, advantages, indoor/outdoor uses and applications for nine transfers, including a heat-resistant line. Also details nameplates for dry pressure-sensitive application. Meyercord Co, 5323 W Lake St, Chicago 44.

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Manufacturers who published following literature asked that requests for copies be made on company letterheads.

FIBERGLASS-REINFORCED PLASTICS–Booklet 32 pp. Outlines properties and handling procedures for polyester, epoxy and foam-in-place resins and contains chart of color-paste dispersions. Discusses contact and spray-up molding. Resin prices are included. Allied Resin Products Corp, Hingham Industrial Center, Hingham, Mass.

PANEL METERS–Catalog P1-1160, 24 pp. Presents specifications, standard ranges and dimensional drawings of miniature and full-size units from ½ to 4½-in. dia. Electronic Sales Div, DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

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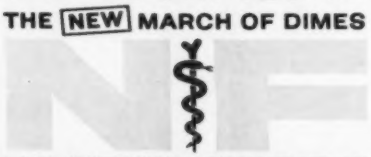

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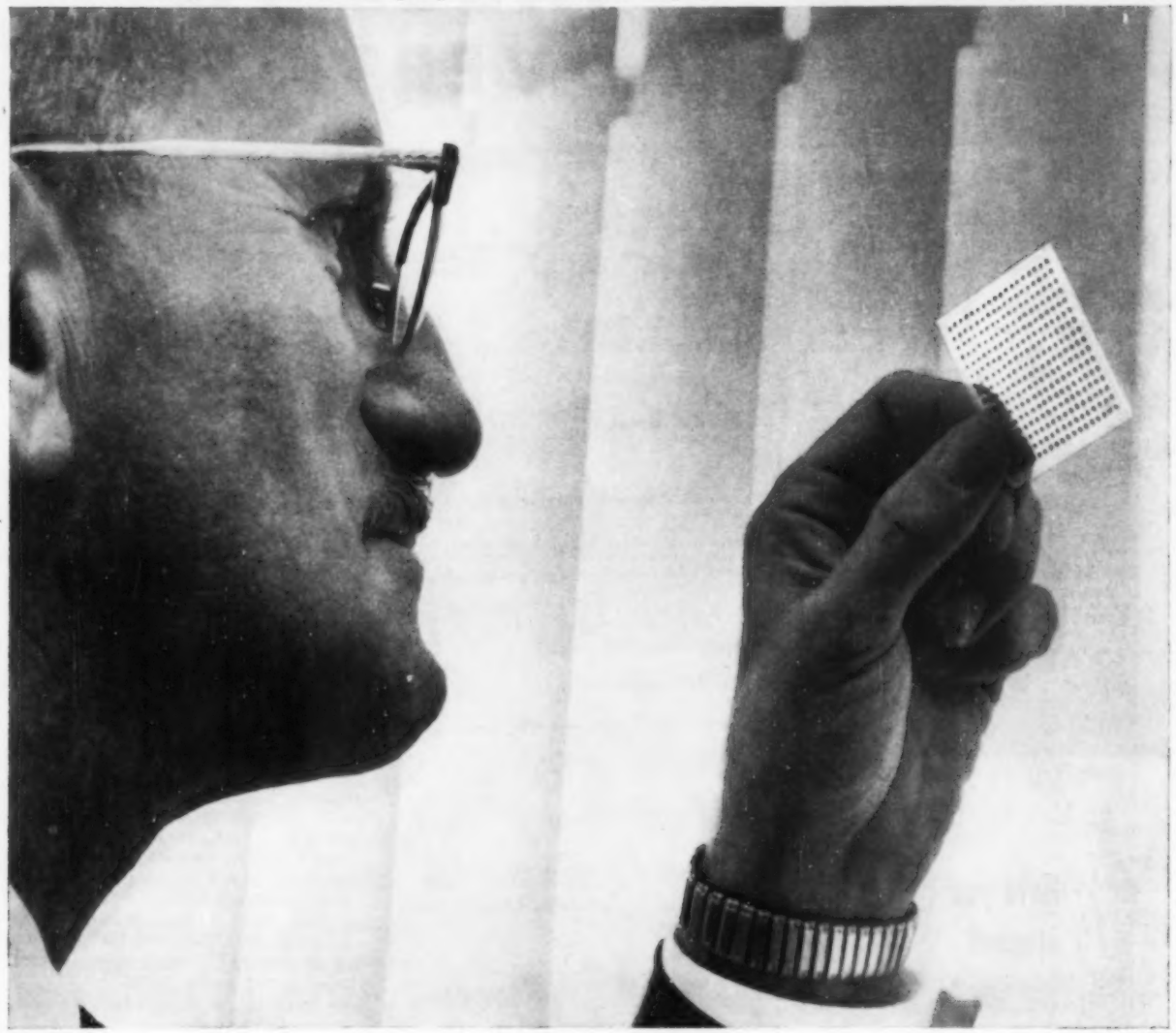

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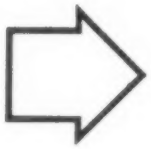

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9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	324	339	354	369	384
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	325	340	355	370	385
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	326	341	356	371	386
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	327	342	357	372	387
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	328	343	358	373	388
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	329	344	359	374	389
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	330	345	360	375	390
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297						
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298						
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299						
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300						

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*MULTIPLE Key No.	PRODUCT ADS Specific Product

(please print or type) *If this is change of address, check box* ☐

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

1	21	41	61	81	101	121	141	161	181	201	221	241	261	281	301	316	331	346	361	376
2	22	42	62	82	102	122	142	162	182	202	222	242	262	282	302	317	332	347	362	377
3	23	43	63	83	103	123	143	163	183	203	223	243	263	283	303	318	333	348	363	378
4	24	44	64	84	104	124	144	164	184	204	224	244	264	284	304	319	334	349	364	379
5	25	45	65	85	105	125	145	165	185	205	225	245	265	285	305	320	335	350	365	380
6	26	46	66	86	106	126	146	166	186	206	226	246	266	286	306	321	336	351	366	381
7	27	47	67	87	107	127	147	167	187	207	227	247	267	287	307	322	337	352	367	382
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16	36	56	76	96	116	136	156	176	196	216	236	256	276	296						
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*MULTIPLE Key No.	PRODUCT ADS Specific Product

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Issue of January 30, 1961

PRODUCT ENGINEERING

Card expires March 30, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

BUSINESS REPLY MAIL
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

Issue of January 30, 1961

PRODUCT ENGINEERING

Card expires March 30, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

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No Postage Stamp Necessary If Mailed in the United States

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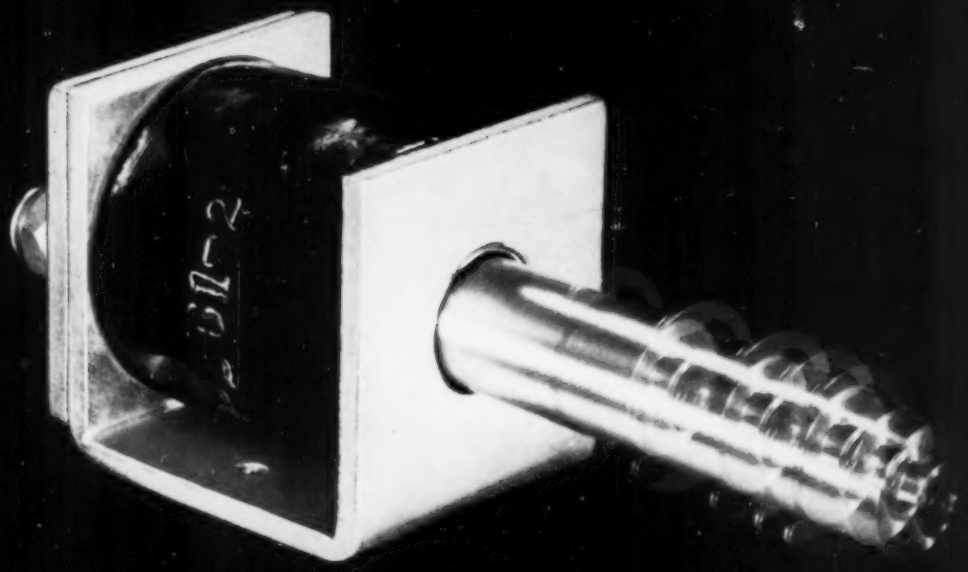
PRODUCT ENGINEERING
330 WEST 42nd STREET
NEW YORK 36, N. Y.

22 FL

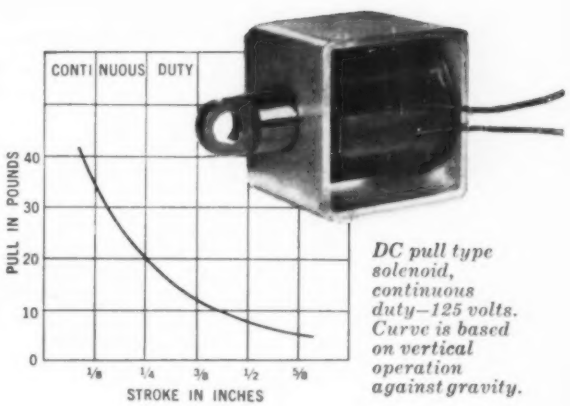
100 MILLION OPERATIONS!



new ASCO solenoid has virtually unlimited life... outstanding economy

In this case "unlimited life" is a simple statement of fact. ASCO's new solenoid is manufactured to such precise tolerances (±0.0005") that wear is virtually non-existent. In ordinary solenoids, the plunger rides loosely in the sleeve—inviting wear. But in ASCO's long-life solenoid, the plunger is guided by a machine tool bearing that assures accurate stroking and reduces friction to an absolute minimum.

Because this solenoid was engineered with quality as the prime consideration, its initial cost is higher. However, it is in fact *the most economical solenoid you can buy* because, once installed, it can practically be forgotten. This solenoid will still be functioning 100 million operations later—long after standard types have been replaced—and replaced—and replaced. For additional information, contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

ASCO Electromagnetic Control

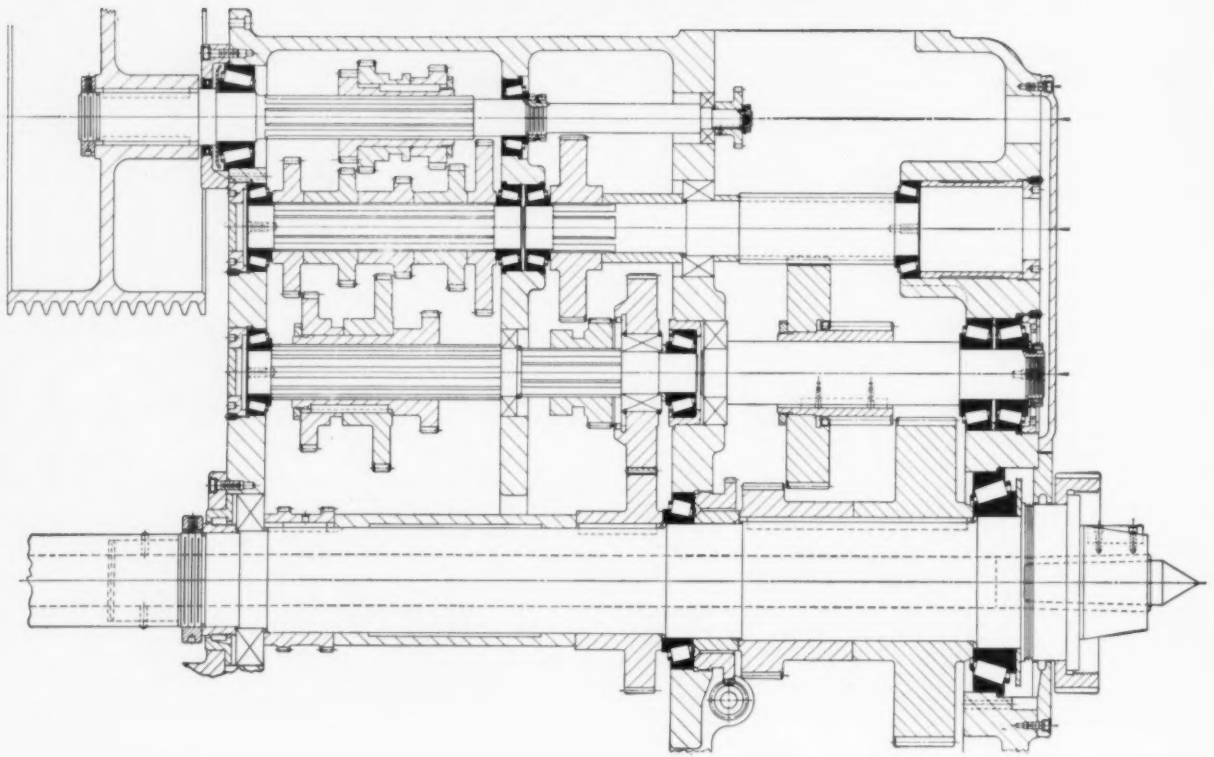
Automatic Switch Co. 54-G HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

CIRCLE 202 ON READER SERVICE CARD

How world's largest tracer lathe assures precision



Engineers of The American Tool Works Co. design maintenance of high precision right into their new Maxi-Swing Tracer Lathe with 16 Timken® tapered roller bearings on the nose and center of the spindle, drive and intermediate shafts. That's because Timken bearings are designed and manufactured to take the big loads from all directions of this machine cutting ¾" deep into work pieces of up to 40 tons. And they do it through a range of 22 speeds, giving rigidity with compact mounting and ease of assembly.

ON-THE-SPOT ENGINEERING SERVICE. Our sales engineers can help you right at the design stage to get the most economical bearing in terms of needed capacity and precision. Why not call them in early?

Industry rolls on

TIMKEN®

tapered roller bearings

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.

CIRCLE 203 ON READER SERVICE CARD